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CIMRON
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SERIES P9000B DIGITAL VOLT- AND VOLT-RATIO METER INSTRUCTION MANUAL

SERIES P9000B
DIGITAL VOLT- AND VOLT-RATIO METER
INSTRUCTION MANUAL

CIMRON
PACIFIC

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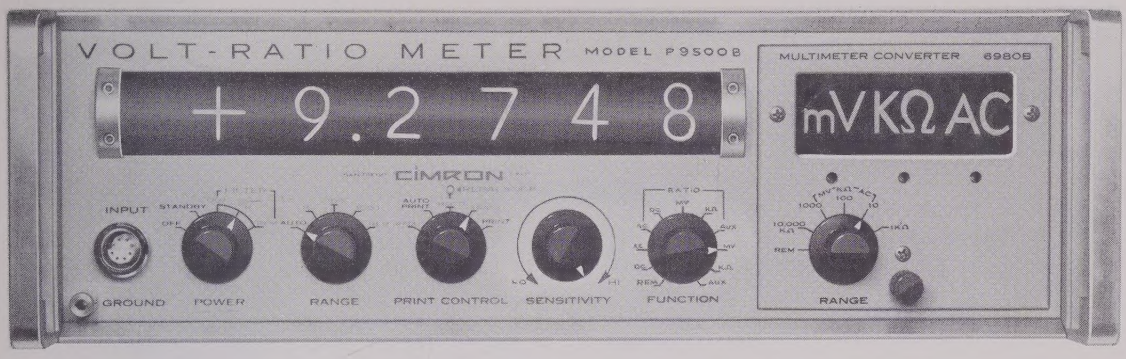

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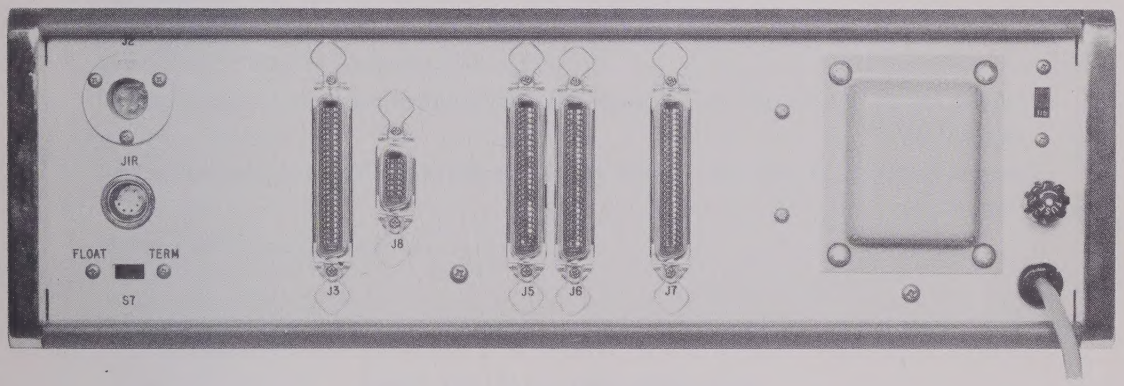
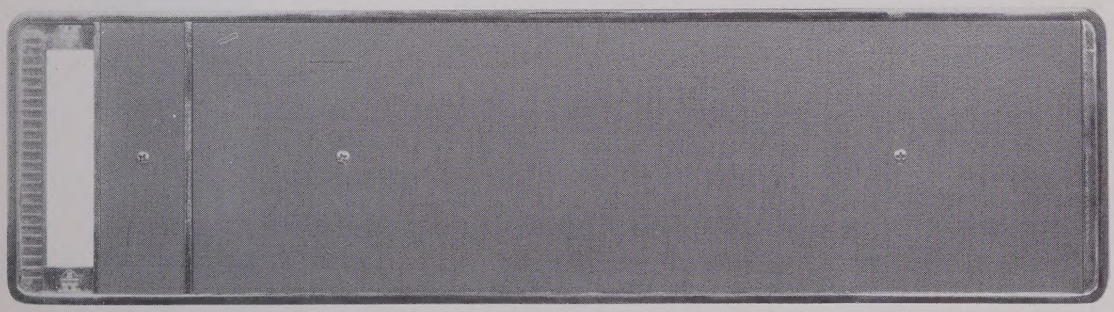


REAR VIEW



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SECTION I

INTRODUCTION

This manual contains complete operation, calibration, and maintenance instructions for all models of the Cimron Series P9000B Digital Voltmeters and Volt-Ratio Meters. A brief description of each section of this manual is given in Table I.

The Cimron Series P9000B consists of Models 9200B, 9300B, 9400B and 9500B instruments. The 9200B Digital Voltmeter, and all other models of the series, are extremely accurate five-digit instruments which measure DC voltages from 0 to ±1000 volts in three manual and automatic ranges of ±10V, ±100V, and ±1000V full scale. By addition of appropriate plug-in accessories, measurement capabilities of the instruments can be expanded to include AC voltages, millivolt DC voltages, and resistance. All models present a visual indication of the value of the input signal.

Model 9300B Digital Volt-Ratio Meter also measures DC ratios from 0 to 100:1 in three manual and automatic ranges of 1:1, 10:1, and 100:1.

Model 9400B Digital Voltmeter provides electrical outputs in the form of 10-line decimal contact closures suitable for operating a printer or other recorder. Various BCD code outputs are available on special order.

Model 9500B Digital Volt-Ratio Meter measures DC ratios from 0 to 100:1 in three manual and automatic ranges of 1:1, 10:1, and 100:1. The Model 9500B also provides electrical outputs in the form of 10-line decimal contact closures suitable for operating a printer or other recording device. Various BCD code outputs are available on special order.

Solid state components are used exclusively, with the exception of the critical circuitry associated with the digital potentiometer. These circuits employ sealed reed relays as the precision switching elements. Virtually all components are mounted on plug-in printed circuit boards, providing an ease of operational and preventive maintenance not usually associated with complex electronic test equipment.

TABLE I

Synopsis of Information in Each Section of the Manual.

SECTION	TITLE	CONTENTS
SECTION I	INTRODUCTION	
SECTION II	SPECIFICATIONS	Specifications which describe in detail the physical and electrical characteristics of the Series 9000 Digital Voltmeters and Digital Volt-Ratiometers.
SECTION III	PRELIMINARY INSPECTION AND OPERATION	This section explains the purpose of the front panel controls and sets forth an inspection procedure for use upon initial receipt of the instrument.
SECTION IV	CALIBRATION AND SPECIFICATION VALIDATION	This section contains a complete calibration procedure, and a method of validating each specification set forth in Section II.
SECTION V	THEORY OF OPERATION	This section contains two parts. The first gives a general description of the principle of operation. The second provides a detailed electrical analysis of each assembly.
SECTION VI	MAINTENANCE	This section contains schematics, component location, and a parts list for each assembly. Oscilloscope pictures of wave forms at critical test points are included to assist in the location of trouble areas.
SECTION VII	RECOMMENDED SPARE PARTS	This section contains recommendations for spare parts and assemblies required to maintain a Series 9000 Digital Voltmeter or Volt-ratiometer for a period of one year.
APPENDIX		Warranty, List of Manufacturers, and list of Abbreviations.

SECTION II

SPECIFICATIONS

INPUT CIRCUIT:	The input signal leads are floating and isolated from case, power line ground and printer output. A guard shield is employed to guarantee maximum input isolation and common-mode rejection.
COMMON MODE REJECTION:	10,000,000:1 (140 db) at DC and 1,000,000:1 (120 db) at 60 cps with 1000 ohms of unbalance in either input lead. Input may be floated up to 1000V DC or peak AC (707V RMS).
NORMAL MODE REJECTION:	At 60 cps, filter out: 54 db, filter in: 74 db.
VOLTAGE RANGE:	0.0000 to ±999.99V DC in three ranges of ±9.9999, ±99.999 and ±999.99V DC. Resolution of 10 microvolts, 1 microvolt and .1 microvolt may be accomplished by use of appropriate plug-in preamplifier.
RANGE SELECTION:	Manual, programmable and automatic.
POLARITY SELECTION:	Automatic.
DISPLAY:	Full five digits using long life readout tubes mounted behind non-reflecting polarizing screen.
ACCURACY:	Within 0.001% of full scale +0.005% of reading after calibration to known standards.
STABILITY:	Short term (24 hours) 0.001% of full scale +0.005% of reading. Long Term (1 year) 0.001% of full scale +0.01% of reading.
RESOLUTION:	0.001% of full scale (= 1 digit).
INPUT RESISTANCE:	Greater than 10,000 megohms at balance on 9.9999V DC range (instrument will measure voltage from a 10 megohm source); greater than 10 megohms independent of balance on 99.999 and 999.99V DC ranges.

RESPONSE TIME: 330 milliseconds average: Maximum balancing time without range and polarity change is 750 milliseconds. Maximum balancing time with range and polarity change is 900 milliseconds. Minimum balancing time is under 7 milliseconds. With filter, balancing times are increased by a factor of 2 to 3.

EXTREME TEMPERATURE RANGE: 0° to +50°C.

TEMPERATURE COEFFICIENT: Derate accuracy 0.0001% of full scale +0.0005% of reading per °C. Derate resolution 1 digit for 20°C temperature rise.

REMOTE CONTROLS: Range (decimal point), function, filter and print control functions may be controlled by external isolated contact closures.

DIGITAL OUTPUT (Model P9400B and P9500B only) The complete digital reading including range and polarity is available on rear mounted connectors. Output information is provided by isolated contacts of reed relays in ten line decimal code. Standard BCD output models also available. Contact ratings are 250V or .5a with a 10 volt-amps maximum.

POWER REQUIREMENTS: 115/230V +10%, 50 to 400 cps, approximately 30 volt-amps. Derate accuracy 0.002% of reading per 10% line voltage change.

WEIGHT: 36 lbs. net; 40 lbs. shipping.

RATIO OPERATION (Model P9300B and P9500B only)

RANGE: .00000:1 to 99.999:1 in three manual, programmable or automatic ranges of .99999:1, 9.9999:1 and 99.999:1.

ACCURACY: Within 0.001% of full scale +0.003% of reading.

EXTERNAL REFERENCE RANGE: Less than ±1 volt DC to ±100 volts DC.

INPUT IMPEDANCE: Greater than 10,000 megohms at balance on the .99999:1 range; greater than 10 megohms independent of balance on the 9.9999:1 and 99.999:1 ranges.

INPUT RESISTANCE FOR EXTERNAL REFERENCE: 100,000 ohms.

POLARITY: Automatic bi-polar.

RESOLUTION (DIGITS): 10/(ref. voltage) or 1 digit whichever is greater.

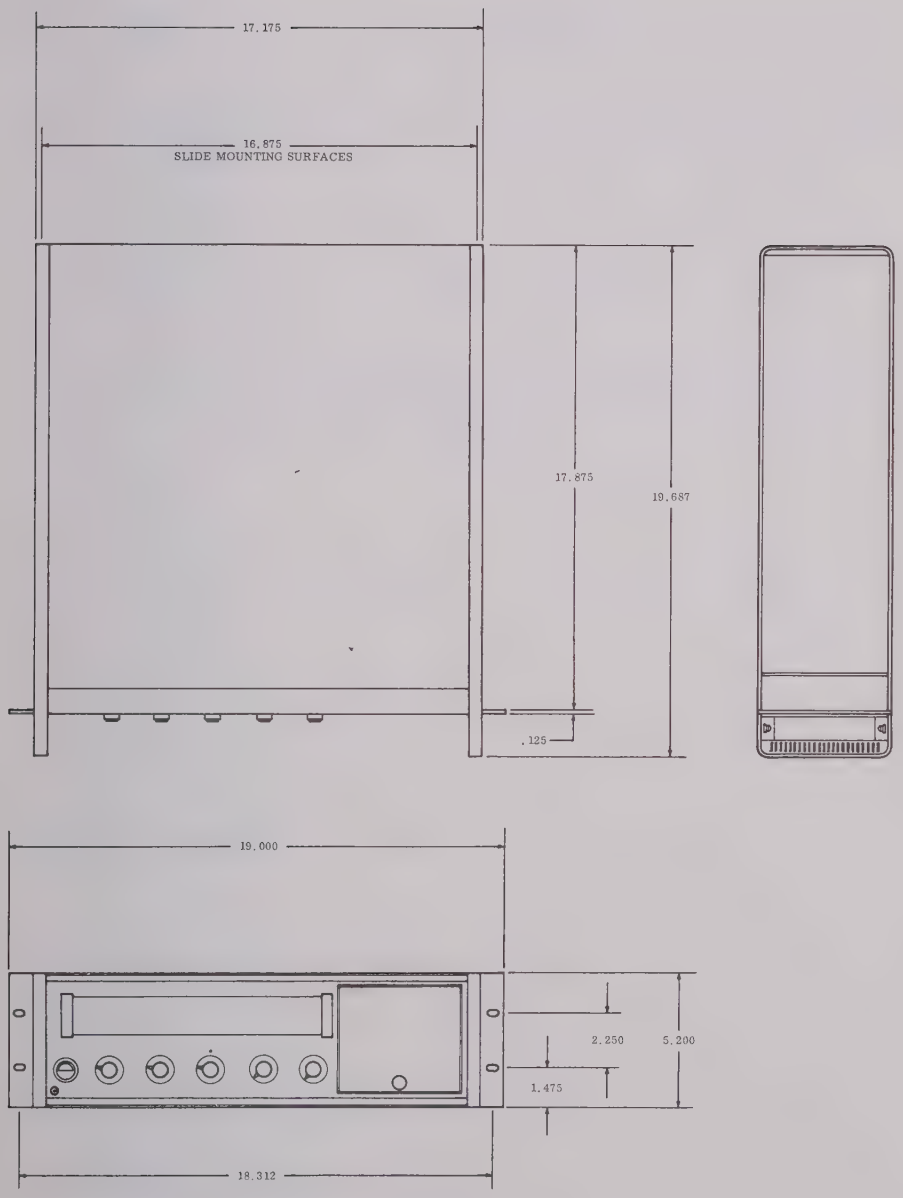

Figure 2-1. Outline Drawings, Series 9000B Digital Volt and Volt-Ratio Meter.

Figure 2-2. Rear Connectors, 9200B and 9300B.

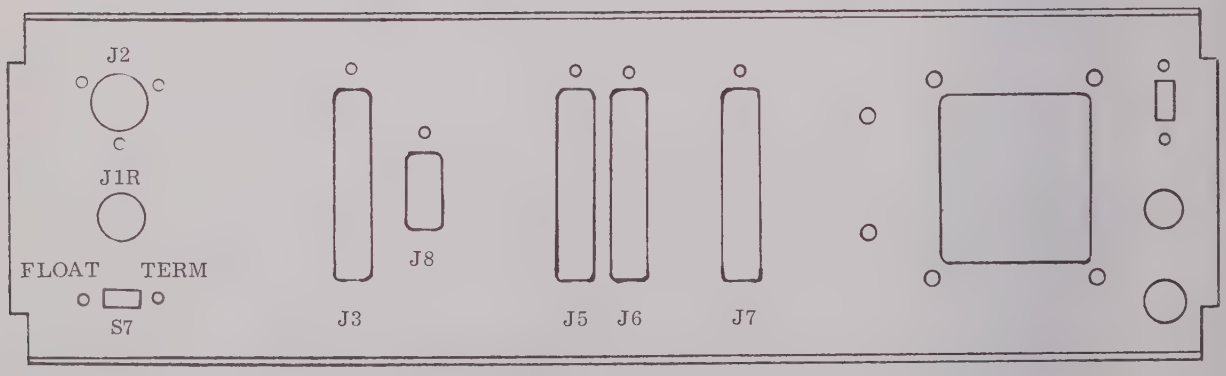

Figure 2-3. Rear Connectors, 9400B and 9500B.

SECTION III

PRELIMINARY INSPECTION AND OPERATION

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INSPECTION AND OPERATION UPON RECEIPT

The digital voltmeter is aligned, calibrated, and tested under severe environmental conditions prior to shipment. The instrument is therefore ready for immediate use upon receipt. The following checks should be made, however, to assure the instrument has suffered no damage in shipment.

1. A visual inspection of the shipping container should be accomplished prior to acceptance from the carrier. If extensive damage of the shipping container is evident, a description of the damage should be noted on the carrier's receipt and signed by the carrier agent. If damage is not apparent until the instrument is unpacked, a claim for concealed damage should be placed with the carrier within 15 days of receipt. All shipping containers and filler material must be kept for inspection.

2. A visual inspection for damage should be accomplished upon removing the instrument from the shipping container. Remove the top cover and guard shield, and check for loose or broken components. Check to see that the printed circuit boards are mated with their connectors and are well seated. Remove the power fuse from its packing container and install the fuse in the fuse holder.

3. Turn the power switch to OFF, the function switch to DC, sensitivity control to HI, the DC range switch to AUTO, and the print control switch to TRACK.

4. Insert the input signal cable assembly into the signal input connector. Short all leads together.

WARNING

Signal input connectors are available on the front and rear panels and are wired in parallel. The unused connector should be covered with its safety cover to protect operating personnel from electric shock.

5. Insert the power cord into a three-wire 115V AC, 60 cps, single phase power source. Turn the power switch to the ON position.

NOTE

Should the instrument be used on a 230V line, a switch is available on the rear panel

6. Position the range switch sequentially to the 10, 100 and 1000 volt positions, and observe that the decimal point shifts to proper position.

7. Connect a low voltage battery between the red and black input leads. The readout should indicate the voltage and polarity of the battery.

8. Reverse the polarity of the input signal; the readout should indicate the polarity change.

9. Remove the battery and short the input leads together. The instrument should return to zero.

NOTE

The liability of Cimron Corporation under the warranty is negated if the instrument is improperly repaired. If trouble is experienced during the above test, refer to appendix for warranty instructions before attempting repair.

OPERATING CONTROLS

All of the controls necessary for normal operation are located on the front panel and are identified in figure 3-1. The function of each control is outlined in table II.

CAUTION

Do not insert plug-in accessories in the digital voltmeter while power is applied.

Figure 3-1. Front Panel Operating Controls.

TABLE II

Front Panel Controls and Their Functions.

CONTROL	POSITION	FUNCTION
POWER	OFF	AC power is removed from the instrument.
	STANDBY	AC power is applied, logic circuits are held inoperative.
	FILTER OUT	AC power is applied, input filter is out.
	FILTER IN	AC power is applied, input filter is in.
	REMOTE	AC power is applied, input filter is remotely controlled.
RANGE	AUTO	The instrument will accept any voltage between 0.0000 and ±999.99V and automatically range to provide the proper input attenuation and correct decimal point position for maximum resolution.
	10	Low range scale. 100uv sensitivity. Used when Auto ranging is not desired.
	100	Medium range scale. 1mv sensitivity. Used when Auto ranging is not desired.
	1000	High range scale. 10mv sensitivity. Used when Auto ranging is not desired.
	REMOTE	Provides for remote control for the 10, 100, or 1000 volt range.
SENSITIVITY	HI THRU LO	The switch determines sensitivity of the instrument. Position HI is equal to 100uv (maximum sensitivity). The sensitivity is decreased as the control is moved toward LO.
FUNCTION	DC	The internal reference supply is connected to the potentiometer. Control of the decimal point is transferred to the DC range.
	AC	The automatic ranging capability of the instrument is removed, locking the DVM in the 10 volt range. Control of the neon decimal indicator is transferred to the plug-in module.
	MV	The automatic ranging capability of the instrument is removed, locking the DVM in the 10 volt range. Control of the neon decimal indicator is transferred to the plug-in module.

TABLE II

Front Panel Controls and Their Functions (Cont.).

CONTROL	POSITION	FUNCTION
FUNCTION (Cont.)	KΩ	The automatic ranging capability of the instrument is removed, locking the DVM in the 10 volt range. Control of the neon decimal indicator is transferred to the plug-in module.
	AUX	The automatic ranging capability of the instrument is removed, locking the DVM in the 10 volt range. Control of the neon decimal indicator is transferred to the plug-in module.
	REMOTE	Six return lines are provided on a rear panel for remote selection of all of the above (FUNCTION CONTROL) positions with the exception of AUX.
	+RATIO (Models 9300B and 9500B only)	The internal reference supply is disconnected. Provisions are made for an external reference supply to be connected across the reference potentiometer through the signal input connector. The polarity of the external reference input and the signal input must be positive.
	-RATIO (Models 9300B and 9500B only)	The internal reference supply is disconnected. Provisions are made for an external reference supply to be connected across the reference potentiometer through the signal input connector. The polarity of the external reference input and the signal input must be negative.
PRINT CONTROL (Models 9400B and 9500B only)	REMOTE	A single relay control line will be externally grounded to establish a track mode; absence of a ground on this line will place the instrument in the hold mode.
	AUTO PRINT	The instrument will track the input signal and upon reaching a balance will issue a print command signal through a rear connector.
	HOLD	Logic circuits are held inoperative unless rebalance "push button" is pressed. This will allow a "one-shot" operation, where the DVM will seek a new null and issue a print command upon completion. At this point, the DVM will be held inoperative again.
	REBALANCE	The DVM will find a new null, issue a print command and return to HOLD mode.
	TRACK	The instrument will track the input but will not issue a print command.
	PRINT	The print position is a momentary contact closure which results in a print command signal at the time of closure. This command is issued without regard for the balance condition of the instrument.

SECTION IV

SPECIFICATIONS VALIDATION AND CALIBRATION

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REFERENCE CONDITIONS

A table of reference and operating conditions for the Series 9000B Digital Voltmeters and Digital Volt-Ratiometers is contained in Section II of this manual. The specifications other than temperature coefficients and line voltage variations should be validated at these reference conditions.

REFERENCE STABILIZATION

To realize the full accuracy capability of the instrument, it is necessary to calibrate the internal reference supply against an extremely accurate voltage source and to adjust the input divider of the instrument to provide an accurate 10:1 and 100:1 signal reduction ratio. The following calibration procedure is based upon the assumption that the external DC power source used exhibits the required stability and its output is known to be better than 0.01%.

Prior to calibration the instrument must be placed in the environment of the calibration area for sufficient time to temperature stabilize. Excessive temperature gradients resulting from a change in environment may cause thermal-voltages to be generated which could affect calibration. A stabilizing time of one hour for each 10°C change in temperature is required.

After the instrument is turned on, a period of 90 minutes must be allowed for the reference supply to stabilize. The output voltage of the reference supply is within 0.01% of its final value in a relatively short period of time. However, if the ultimate accuracy is to be realized, complete stabilization is necessary before calibration is attempted.

ADJUSTMENT

The following adjustments when required should be accomplished in the order described below. These adjustments are considered operational in nature in that they do not affect the accuracy of the instrument. For this reason, adjustment should be required only after major changes such as the replacement of a plug-in assembly. When complete readjustment and recalibration is required, adjustment procedures should be accomplished prior to calibrating the reference supply and input divider (attenuator).

The following equipment is required to perform these adjustments:

1. Precision, stable DC power supply.
2. Linear voltage divider.
3. Dual beam oscilloscope with a sensitivity of 200 microvolts per centimeter.

Remove the top cover to expose the large inner guard shield. All test points required for the alignment and calibration of the Series 9000B instruments are identified on the shield, as shown in figure 4-1.

Position the instrument controls as follows:

FUNCTION	DC
RANGE	AUTO
PRINT CONTROL	TRACK
SENSITIVITY	HI
POWER/FILTER	FILTER IN

To review the necessary waveforms, position the oscilloscope controls as follows:

TRIGGER SELECTOR	EXTERNAL DC (+)
TIME/CM	2MS/CM
SENSITIVITY	1V/CM (X1 PROBE)

BALANCE ADJUSTMENT

Connect the oscilloscope to the instrument as follows:

SIGNAL COMMON	COMMON
CHANNEL A INPUT	TP13
EXTERNAL TRIGGER	TP14

Connect the power supply, voltage divider and instrument as shown in figure 4-2 and proceed as follows:

1. Adjust the DC power supply for +1 volt output.
2. Adjust the output of the voltage divider for a null condition (figure 4-3) at 500mv.
3. Observe the reading on the instrument and the exact setting of the voltage divider.
4. Increase the setting of the voltage divider by 100 microvolts.
5. Note that the instrument reading increases one digit.
6. Adjust the output of the voltage divider to obtain a null condition.
7. Observe the voltmeter reading and the exact setting of the voltage divider.
8. Decrease the voltage divider output by 100 microvolts.
9. Note that the voltmeter reading decreases by 1 digit.
10. Vary the Balance Adjustment for best equality of up and down sensitivities.

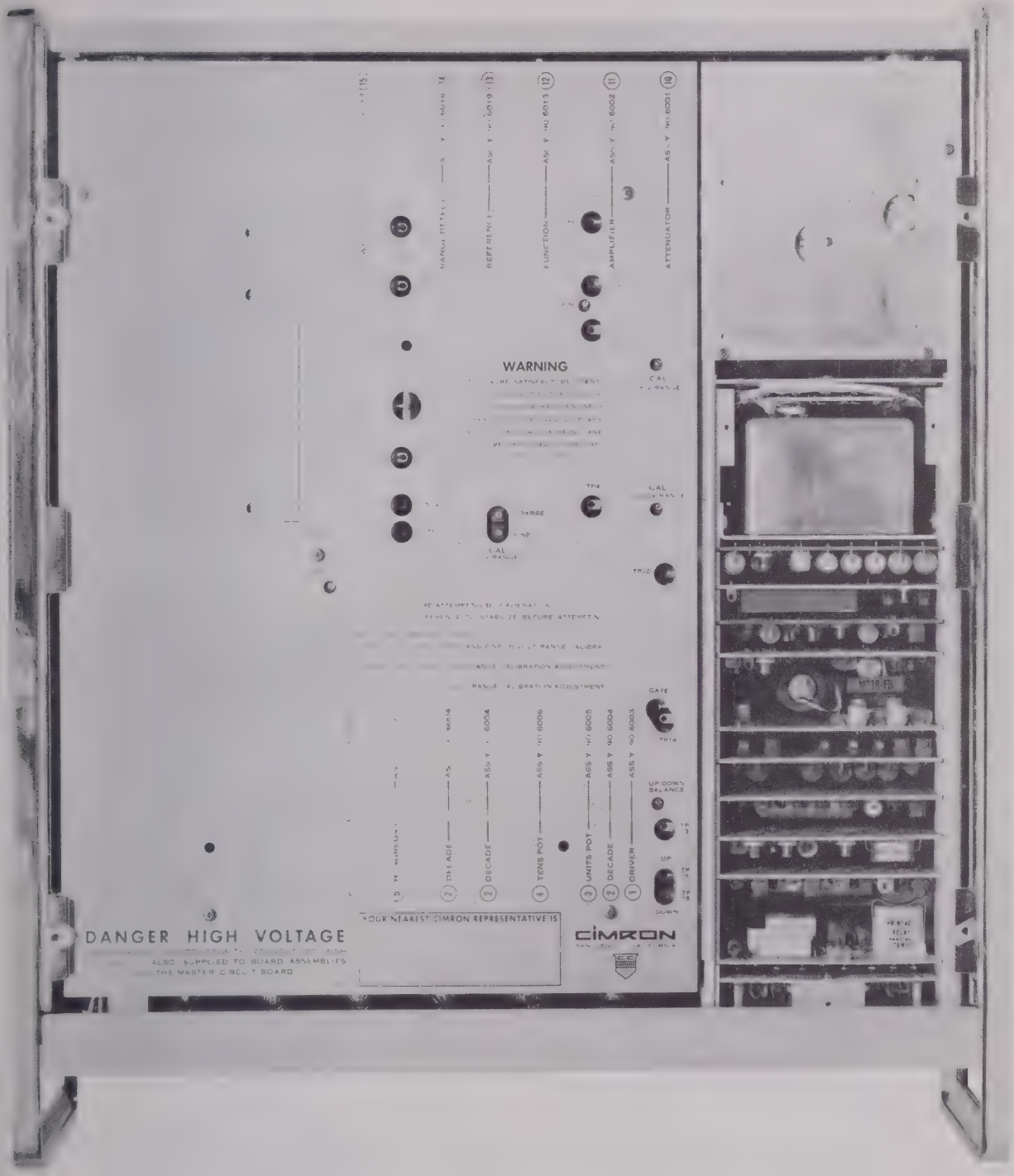


Figure 4-1. Calibration Controls, Series 9000B.

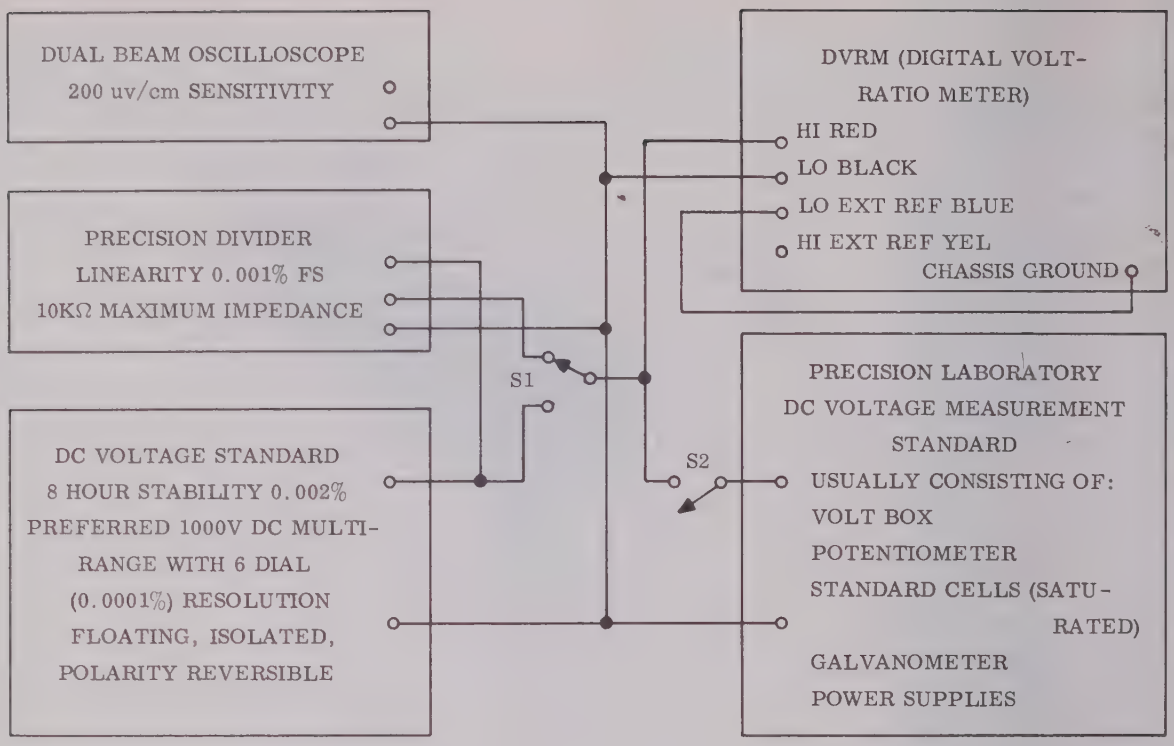


Figure 4-2. Calibration Equipment Setup.

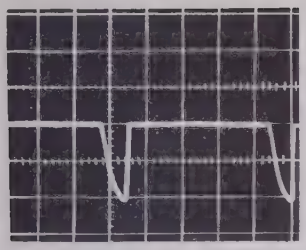
GAIN ADJUSTMENT

Connect the oscilloscope as follows:

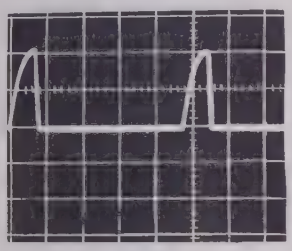
SIGNAL COMMON	COMMON
CHANNEL A INPUT	TP13
EXTERNAL TRIGGER	TP14

Connect the power supply, voltage divider and instrument as shown in figure 4-2.

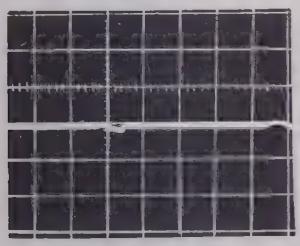
1. Adjust the DC power supply for +1 volt output.
2. Set the precision voltage divider for 0.5 volt output.
3. Slowly increase and then decrease the output of the voltage divider.
4. Observe that either a positive or negative pulse can be made to appear at the demodulator output terminal (TP13). Examples of such errors are shown in figure 4-3.
5. Adjust the output of the voltage divider for minimum amplitude pulses.
6. Observe the reading on the instrument and the exact setting of the voltage divider.
7. Increase the setting of the voltage divider by 100 microvolts.
8. Vary the Gain Adjustment to cause the instrument reading to increase by 100 microvolts.



Negative pulse due to input voltage lower than DVM reading.



Positive pulse due to input voltage higher than DVM reading.



Null.

Figure 4-3. Demodulator Output, TP13.

9. Adjust the voltage divider to obtain a new null condition. Observe the voltmeter reading and voltage divider setting. Repeat paragraphs 7 through 9 to obtain an optimum adjustment.

TRANSFER ADJUSTMENT

Connect the power supply, voltage divider and instrument as shown in figure 4-2.

1. Adjust the DC power supply for an output of 3.0 volts in a positive polarity.

2. Adjust the voltage divider as required to obtain a reading of +0.9999 on the instrument.

3. Gradually increase the voltage divider output from null until the voltmeter has progressed through the decade transfer to a reading of 1.0000.

4. Reverse the polarity of the power supply and repeat paragraphs 1 through 3.

5. Vary the Transfer Adjustment for a compromise setting which will allow the best transfers. If improperly positioned, the Transfer Adjustment will cause the voltmeter to oscillate between 0.9999 and 1.0000 in one or the other polarity.

REFERENCE SUPPLY CALIBRATION

To accurately calibrate the reference supply the following test equipment is required:

1. Precision, stable DC power supply.

2. Dual beam oscilloscope with a sensitivity of 200 microvolts per centimeter.

Remove the top cover to expose the large inner guard shield. All test points required for the calibration of the instrument are identified on the shield.

To review the necessary waveforms, connect the oscilloscope as follows:

CHANNEL A INPUT	TP13
EXTERNAL TRIGGER	TP14
SIGNAL COMMON	COMMON

Position the oscilloscope controls as follows:

TRIGGER SELECTOR	EXTERNAL DC (+)
TIME/CM	2MS/CM
SENSITIVITY	1V/CM (X1 PROBE)

Position the instrument controls as follows:

FUNCTION	DC
RANGE	AUTO
PRINT CONTROL	TRACK
SENSITIVITY	HI
POWER/FILTER	FILTER IN

Connect the voltmeter input (figure 4-2) directly to the DC power supply, using switch S1.

SIGNAL HI (RED)	+ DC OUTPUT
SIGNAL LO (BLACK)	- DC OUTPUT
EXTERNAL REFERENCE LO (BLUE)	CHASSIS GROUND TERMINAL
EXTERNAL RATIO HI (YELLOW)	NOT CONNECTED

To accurately calibrate the reference supply proceed as follows:

1. Adjust the DC power supply for an output of 9.9000 volts ±0.01%.

2. Note the reading displayed on the instrument and observe the null. If the reading differs from the value of voltage in step 1, sequentially adjust the Coarse and Fine trim potentiometers for the 10V range to obtain the correct reading. After adjusting, tap each control lightly to assure that the wiper arm is properly seated. This adjustment should be possi- to within ±one digit of the power supply voltage.

ATTENUATOR CALIBRATION

The attenuator adjustment consists of setting the trim potentiometers in the input divider to provide an accurate 10:1 signal reduction on the 100V range and a 100:1 signal reduction on the 1000V range. The following test equipment is required to accurately adjust the input divider.

1. Precision, stable, DC power supply.

2. Dual beam oscilloscope with a 200 microvolt sensitivity.

To review the necessary waveforms connect the oscilloscope as follows:

CHANNEL A INPUT	TP13
EXTERNAL TRIGGER	TP14
SIGNAL COMMON	COMMON

Position the oscilloscope controls as follows:

TRIGGER SELECTOR	EXTERNAL DC (+)
TIME/CM	25MS/CM
SENSITIVITY	1V/CM (X1 PROBE)

Position the instrument controls as follows:

FUNCTION	DC
RANGE	AUTO
PRINT CONTROL	TRACK
SENSITIVITY	HI
POWER/FILTER	FILTER IN

Connect the output of the power supply (figure 4-2) to the input of the instrument using switch S1.

SIGNAL HI (RED)	+ DC OUTPUT
SIGNAL LO (BLACK)	- DC OUTPUT
EXTERNAL RATIO LO (BLUE)	CHASSIS GROUND TERMINAL
EXTERNAL RATIO HI (YELLOW)	NOT CONNECTED

To adjust the range attenuator proceed as follows:

1. Adjust the DC power supply to obtain an output of 99.900 volts ±0.01%.

2. Note the voltage displayed on the instrument readout. If the reading differs from the power supply voltage by more than ±0.01%, adjust the 100V Range trim potentiometer to obtain a reading within tolerance.

3. Adjust the DC power supply to obtain an output of 999.00 volts ±0.01%.

4. Note the voltage displayed on the instrument readout. If the reading differs from the power supply voltage by more than ±0.01%, adjust the 1000V Range trim potentiometer to obtain a reading within tolerance.

RATIO OPERATION

The Model 9300B and 9500B are designed to measure voltages by comparing an unknown voltage with a known voltage of the same polarity. The known voltage is referred to as the reference voltage. When operating as a voltmeter the reference voltage is supplied from an internal source. In ratio operation, however, the reference voltage is supplied externally and may be any voltage from ±1.0 volt to ±100 volts.

The instrument displays the quotient of the unknown voltage divided by the external reference voltage. When making ratio measurements the instrument automatically selects the proper range if the RANGE switch is in AUTO position. Ratio measurements are usually of an unknown voltage of lesser value than the external reference voltage. The range switch should be in the Auto or 10 position under these circumstances.

The following test equipment is required to demonstrate the ratio capability of the instrument:

1. Precision, stable DC power supply.

2. Voltage Divider with linearity to 0.005%.

Position the instrument controls as follows:

FUNCTION	+ RATIO
RANGE	AUTO
PRINT	TRACK
SENSITIVITY	HI
POWER/FILTER	FILTER IN

Connect the equipment as shown in figure 4-4 and proceed as follows:

1. Adjust the power supply to obtain 10.0V output.

2. Adjust the voltage divider to a selected voltage ratio.

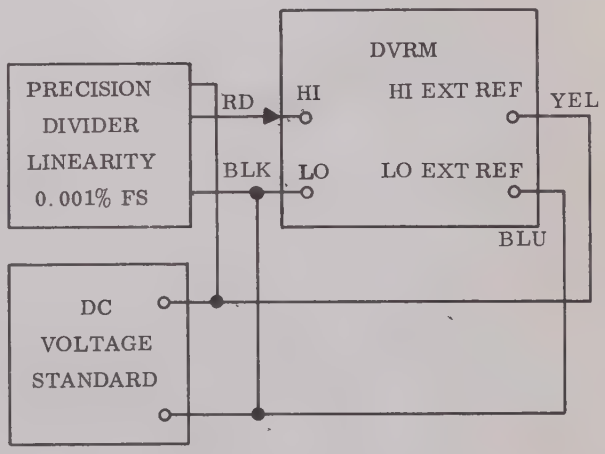


Figure 4-4. Ratio Test Equipment Setup.

3. Note that the reading on the instrument does not vary from the selected ratio by more than ±0.005% of reading ±0.002% of full scale.

4. Adjust the power supply to obtain 3.0 volts output.

5. Adjust the voltage divider to a selected voltage ratio.

6. Note that the reading on the instrument does not vary from the ratio selected by more than ±0.015% of reading ±0.03% of full scale.

7. Adjust the power supply to obtain 1.0 volt output.

8. Adjust the voltage divider to a selected voltage ratio.

9. Note that the reading obtained on the instrument does not vary from the ratio selected by more than ±0.05% of reading ±0.01% of full scale.

10. Reverse the power supply connections.

11. Position the Function Switch on the instrument to - Ratio.

12. Repeat paragraphs 1 through 9 for a minus ratio.

RESPONSE TIME

To accurately measure the step response time of the instrument the following test equipment is required:

1. Precision, stable DC power supply.

2. Dual beam oscilloscope with 200 microvolt sensitivity.

Connect the equipment as shown in figure 4-5. The oscilloscope connections are as follows:

CHANNEL A INPUT	TP12
SIGNAL COMMON	COMMON
EXTERNAL TRIGGER	TP13

To review the necessary waveform position the oscilloscope controls as follows:

1. Set up oscilloscope for single sweep operation with a sweep time of 0.1 second per centimeter.

2. Adjust the oscilloscope sensitivity to 1 volt per centimeter.

Step response time is specified as a maximum of 750 milliseconds with an average of 330 milliseconds. It can be considered as the time for the instrument to reach a null from a previous reading without a range or polarity change. This measurement is accomplished as follows:

1. Adjust the DC power supply to any voltage less than 10.0 volts.

2. Allow the instrument to null.

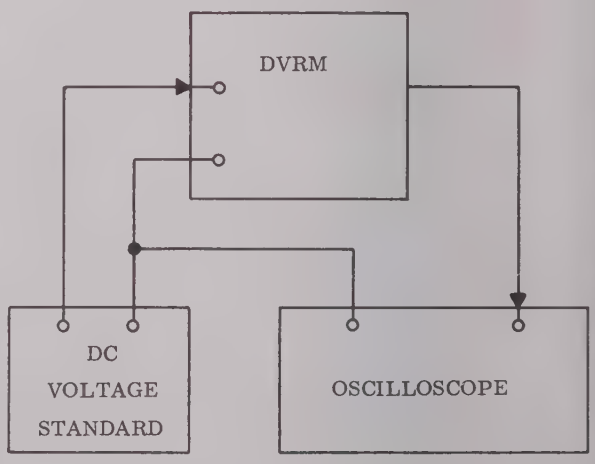


Figure 4-5. Response Time Setup.

3. Position the PRINT CONTROL to HOLD.

4. Adjust the DC power supply to another voltage less than 10.0 volts, and allow sufficient time for the voltage to become stabilized. A period of five seconds is recommended.

5. Depress the REBALANCE push-button and observe the sweep on the oscilloscope. Error signals will be apparent on the sweep until the meter has nulled. The duration of these error signals corresponds to the step response time of the instrument.

NOTE

The print command pulse from the instrument produces an extra signal at approximately 0.2 seconds after null is reached. The print command should not be included in the step response time.

INPUT RESISTANCE

In validating the instrument specifications it is necessary to measure input resistance. This is accomplished by measuring the input current at balance and calculating the resistance.

The following equipment is required to perform the input resistance measurement:

1. Resistor: 10 megohm ±0.25%

2. Precision, stable DC power supply.

3. A linear voltage divider.

NOTE

Input shielding may be necessary in a noisy environment. High source impedance necessitates a 1 uf. shunt capacitor to stabilize the instrument readout.

Position the instrument controls as follows:

FUNCTION	DC
RANGE	AUTO
PRINT CONTROL	TRACK
SENSITIVITY	HI
POWER/FILTER	FILTER IN

Arrange the test equipment as shown in figure 4-2 and perform the following tests:

1. Adjust the power supply to obtain 10.000 volts output.

2. Adjust the voltage divider to 99995.

3. Note the reading displayed on the instrument. Insert the 10 megohm resistor in series with the SIGNAL HI (RED) lead and the voltage divider. A drop of 0.0100 volts across the 10 megohm resistor as indicated by the instrument reading represents a 1000 megohm input resistance at DC. The following computations illustrate the validity of the statement:

$$\text{INPUT CURRENT} = \frac{\Delta E}{10_6}$$

$$\text{INPUT RESISTANCE} = \frac{\text{Instrument Reading}}{\text{Input Current}}$$

AC COMMON MODE REJECTION

The effect of common mode signals on the operation of the instrument is a further parameter which is tested during the validation of the instrument specification. This is accomplished by applying a DC voltage

of less than 2.0 volts between the SIGNAL HI (RED) and SIGNAL COMMON (BLACK) inputs to the instrument. A common mode signal (60 cps or 400 cps) is then inserted between Signal Common and chassis ground. This common mode signal is then slowly increased until instability is noted in the least significant decade of the instrument. At this point the error voltage resulting from the common mode signal is approximately 100 microvolts. The common mode rejection capability is then established by determining the ratio of the common mode signal to the resulting error voltage (100 microvolts) and expressing the solution in decibels.

The following test equipment is required to perform the AC common mode rejection measurement:

1. Wide band audio oscillator.
2. Mercury cell, 1.34 volts.
3. RMS voltmeter capable of measuring the amplitude of the common mode signal.
4. Resistors: 1K 1/2W±5%; 10K 1/2W±5%; 100Ω 1/2W ±5%.

Position the instrument controls as follows:

FUNCTION	DC
RANGE	AUTO
PRINT CONTROL	TRACK
SENSITIVITY	HI
POWER FILTER	FILTER IN

Prior to determining the AC common mode rejection ratio, measure the resistance between the signal common and chassis. The ohmmeter used should indicate a resistance of greater than 1000 megohms.

Position the instrument controls as follows:

FUNCTION	DC
RANGE	AUTO
SENSITIVITY	HI
PRINT CONTROL	TRACK
POWER/FILTER	FILTER IN

Arrange the test equipment as shown in figure 4-6 and perform the following steps:

1. With no AC voltage supplied, allow the instrument to null and observe the reading.
2. Insert in series with the SIGNAL HI (RED) lead and the SIGNAL LOW (BLACK) lead, the value of resistor applicable to the specific portion of the common mode measurement being made.
3. Adjust the oscillator frequency to either 60 or 400 cycles.
4. Slowly increase the output of the oscillator until an instability occurs in the least significant decade on the instrument.

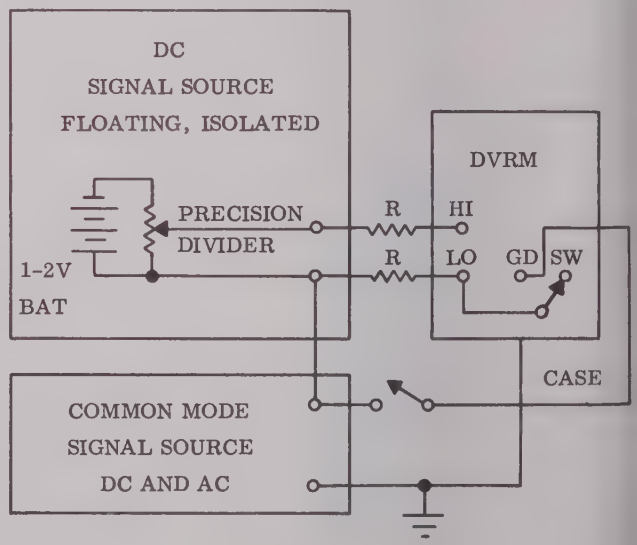


Figure 4-6. Common Mode Interference Ratio Test Setup.

5. Vary the voltage divider setting slightly to stabilize the instrument.

6. Again increase the output of the oscillator until instability occurs.

7. Measure the peak AC voltage at the output of the audio oscillator.

8. Calculate the common mode rejection ratio as shown below.

EM = Amplitude of common mode signal

ED = Amplitude of error signal resulting

CMR = Common mode rejection ratio

$$CMR = 20 \log \frac{EM}{ED}$$

NOTE

When the guard of the instrument is to be driven from an external source the switch at the rear of the instrument must be positioned for floating operation. Under these conditions the guard input must be applied to Pin 7 of the front panel signal input connector J-1F, Pin 7 of the rear panel signal input connector J-1R or Pin 19 of connector J3 on the rear panel of the instrument.

CAUTION

Where the guard shield is driven from the common mode voltage source the voltage between the guard shield and the signal LO must be limited to 50V DC or peak AC. This voltage will be that developed across the unbalanced resistor in series with the low input of the instrument. Maximum common mode voltage is limited to 500 V DC or RMS AC.

The DC rejection characteristics of the instrument indicate its ability to measure low amplitude voltages accurately when the desired signal is floating on a large DC potential. The amount of DC which can be rejected is chosen as that voltage which, when impressed between signal LO and chassis ground, will cause a change in the least significant decade of the instrument. The procedure to be followed when validating this portion of the specification is identical with the procedure for AC common mode rejection ratios, except that a DC power supply is substituted for the audio oscillator. The rejection ratio is calculated, using the same formula as is used for the AC rejection ratio.

NORMAL MODE REJECTION RATIOS

The normal mode rejection ratio is a measurement of the ability of the instrument to reject an AC signal common to both the signal HI and the signal LO input connection while measuring a low level DC voltage.

The following equipment is required to perform the normal mode interference ratio measurement:

1. Wide band audio oscillator.

2. Mercury cell, 1.34 volts.

3. RMS voltmeter, capable of measuring the amplitude of the common mode signal.

4. A linear voltage divider.

Position the instrument controls as follows:

FUNCTION	DC
RANGE	AUTO
PRINT CONTROL	TRACK
SENSITIVITY	HI
POWER/FILTER	FILTER OUT

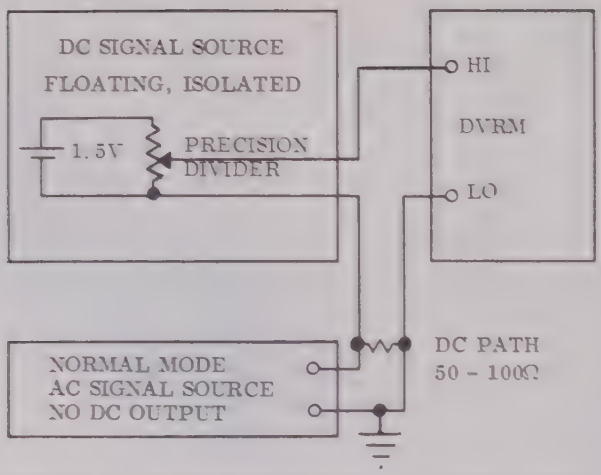


Figure 4-7. Normal Mode Interference Ratio Test Setup

Arrange the test equipment as shown in figure 4-7 and perform the following steps:

1. Adjust the oscillator to produce a 60 cps or a 380 cps signal dependent upon the specification being validated.

2. Position the POWER/FILTER switch on the instrument to either FILTER IN or FILTER OUT dependent upon the specification being validated.

3. With the AC signal at zero and with no DC present at the output of the signal generator, allow the instrument to null and observe the reading obtained.

4. Slowly increase the AC signal output until an instability is detected in the last digit of the instrument.

5. Adjust the voltage divider to cause the instrument to stabilize.

NOTE

If it is not possible to stabilize the instrument with a slight change in the voltage divider setting, the AC normal mode signal may be too high. The desired point of measurement is when the AC signal is of sufficient amplitude to just cause instability in the instrument.

6. Compute the normal mode rejection ratio as follows:

EM = Amplitude of normal mode signal.
ED = Amplitude of error signal resulting.
NMR = Normal mode rejection ratio.

$$NMR = 20 \log \frac{EM}{ED}$$

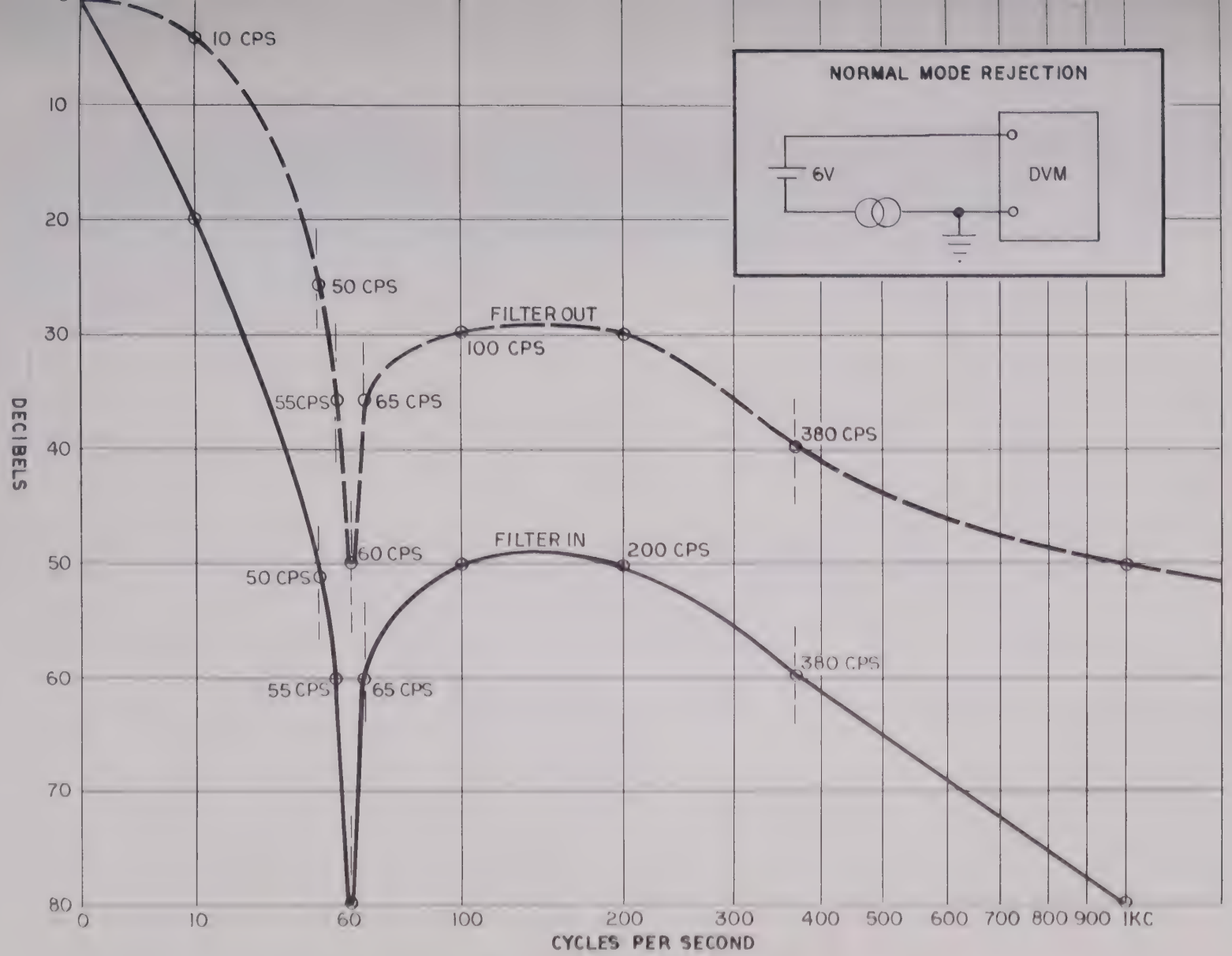


Figure 4-8. Normal Mode Rejection.

SECTION V

THEORY OF OPERATION

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GENERAL

The 9000 Series Digital Voltmeters and Digital Volt-Ratiometers are essentially closed-loop digital servo systems. The principle of operation is one of voltage comparison. The value of an unknown voltage is determined by comparing it with a known voltage. The known voltage is obtained by dividing a stable, internally-generated reference voltage across a series of fixed resistors (figure 5-1). The value of the unknown voltage is determined by moving the potentiometer arm until the sensing device indicates the value of the voltages to be equal. This is referred to as a condition of "null" or "balance".

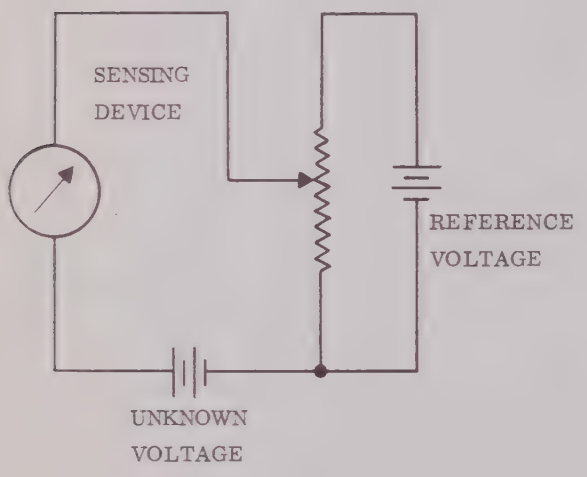


Figure 5-1. Basic Operating Principle of a DVM.

The basic method of comparison is a servo which examines the input voltage and then the known reference voltage. If a voltage difference is detected, the reference voltage is varied until a balance is attained. The input voltage is automatically attenuated as necessary to ensure that its value is less than the reference voltage. In doing this the voltmeter senses as little as 100 microvolt variance between the value of the input and reference voltages. This requires very stable resistors; components possessing low temperature coefficients; low drift, high gain amplifiers; and the ability to reject unwanted signals such as those caused by ground loops. The ability to ascertain the unknown voltage in a minimum time requires a logic that can approach the final reading in the fastest manner possible. The logic used in the 9000B instruments provides great flexibility and is able to select the shortest of several different routes to achieve balance in exceptionally short time.

The following circuit description traces the input signal through the digital voltmeter, with a detailed analysis of each assembly, including the operation of various logic and counting sequences. A schematic of each assembly is located in Section VI and can be folded out while reading the description in Section V. Both the description and the schematic are in sequential order and have been assigned corresponding numbers.

SIGNAL CIRCUITS BLOCK DIAGRAM (Schematic 1)

Digital Voltmeter input connections are shown on the left hand side of the drawing. Signal inputs are applied to either of the parallel input connectors, J1F and J1R. These two connectors are paralleled inside the instrument so that either input may be used. From the input connector the signal is fed into the input selector. The input selector is controlled by the front panel FUNCTION selector and by a diode matrix in the plug-in accessory, if installed. The input selector will automatically direct the input signal (i.e., signal high and signal low) to either the plug-in unit or directly to the attenuator in the digital voltmeter. K12 and K56 feed the signal to the plug-in unit. The output from the plug-in unit is connected through K34 into the attenuator of the digital voltmeter. The attenuator provides three ranges, 10V, 100V, 1000V full scale. The range switches are controlled by the range and polarity board. The range and polarity board in turn is controlled by either the manual front

panel switch or automatically by the logic of the DVM. From the attenuator the signal is directed into the input filter. The filter output signal is directed into a chopper. The chopper is a solid state modulator in a sealed module which contains not only the chopper circuit but also an internal oscillator. The electrical equivalent of the chopper is shown in the block diagram as a mechanical chopper. The chopper is driven directly by the oscillator which also provides a trigger output to a gate generator on the driver board. This trigger output is used in the gate generator to synchronize a demodulator or clamp to the chopped input signal. The chopper continuously compares the input signal with the output of a precision potentiometer. The output of this precision potentiometer is identified as "pot arm". If both the input signal and the output of the precision potentiometer are equal, no error signal between the two can be detected. If there is a difference between the two voltages, an error signal is generated by the chopper and coupled into the amplifier. When an error signal is detected, the digital voltmeter is said to be off balance. If an error cannot be detected the digital voltmeter is at balance.

The amplifier is divided into three sections shown as three individual amplifier assemblies, a preamplifier, an intermediate amplifier, and an output amplifier. The error signal is fed directly from the chopper arm into the preamplifier. The preamplifier provides a gain of approximately 20 db. (For exact calibration see detailed calibration procedures in Section IV.) A clearly identified trim potentiometer provides gain adjustment in the preamplifier. From the preamplifier output the signal is fed into the sensitivity circuit. The sensitivity circuit is shown on the block diagram as a simple potentiometer. From the arm or wiper of the sensitivity circuit, the signal is fed to the intermediate amplifier where it is amplified by approximately 26 db before it is applied to the output amplifier stage. The overall signal gain in the amplifier assembly is approximately 66 db. Also shown in the amplifier block is an amplifier polarity control, composed of transistor switches which receive signals from the range and polarity board. The switches control the output polarity of the amplifier to match the internal reference. When the positive switch is on, the amplifier output is inverted. When the negative switch is on, the output is not inverted. This is clearly defined in the amplifier description.

The signal from the output amplifier stage is applied to the clamp. The clamp is driven from the gate generator which is synchronized to the oscillator. The clamp circuit will permit the signal to pass only during a very short (2 milliseconds) period. Since the clamp circuit is synchronized to the chopper, it is a demodulator. From the clamp output, the signal is fed simultaneously into the up and down drivers. One of these drivers responds to a positive signal and the other responds to a negative signal. Whichever driver fires first will cause an interlock to prevent the other driver from firing. This guarantees that there can only be one drive signal at a time, either up, down, or none (balance). The drive signals are directed into the logic of the decade boards. The up drive signal is directed into the unit decade first and the down drive signal is directed into the 10K decade first. The decades have their outputs connected to the precision potentiometer and also to the readout. The digitized servo system (with the logic up and down pulses) commands the decades to move into certain number positions. The decades contain drivers which control the positions of the switches of the potentiometer and the numbers which are displayed in the readout. The precision potentiometer 10K decade input (potentiometer high) is connected to a switch on the function board. This switch has two positions, ratio and DC. It is shown in the DC position. In DC the potentiometer high is connected to the reference assembly. Potentiometer low is always connected to signal low which is also DVM circuit common.

The reference is an ultra stable supply voltage calibrated to provide a precise 10V for the precision potentiometer. The polarity of the reference is controlled from the polarity board and is synchronized

through the logic of the DVM to the input signal polarity. For operation as a ratiometer, the potentiometer high is connected through the switch on the function board to an external input terminal.

The instrument has an inner guard shield which is entirely isolated from power line ground and DVM signal circuits. A switch for the termination of the guard shield, S7, is shown in the left bottom corner of the block diagram. S7 is located on the rear panel and terminates the guard shield to signal low or allows it to be in a floating condition. Provisions are made on the programming connector so that the guard shield may be terminated either by remote contact closure or at the signal source. The detailed information for the different connectors is shown in the master wiring schematic.

LOGIC DESCRIPTION (Schematic 2)

This logic represents an entirely new approach to tracking logic. A number or counting system which prefers the odd numbers and skips the even numbers is used. Since the digital voltmeter has many self-checking features, it is very often possible to make a failure analysis from a misbehavior in the readout. However, to interpret a misbehavior it is absolutely mandatory that the logic and counting sequence is completely understood. To advance the count from 0 to 9 in any decade but the ten thousand, the instrument counts in the sequence: 1, 3, 5, 7, 9. Obviously the logic cannot ignore the even numbers entirely; it simply skips them. At any time, the logic is able to reverse its decision and take one step backwards to the next lower even number. For example, to count to the number 6 from 0, the counting sequence is: 1, 3, 5, 7, and one step backward to 6. If a decade count is the decimal number 2, and is to advance to the number 8, the instrument will advance directly to the next higher odd number. The counting sequence is therefore: 2, 3, 5, 7, 9, and one step back to 8. It is important to remember that the logic counts up by odd numbers in the units, tens, hundreds, and thousands decades. The ten thousands decade, however, counts in a conventional manner (i.e., 1, 2, 3, 4, 5, etc.).

Each decade logic is divided into two sections. The trinary section deals strictly with odd or even number sets. The hexanary section deals with number pairs: (0+1), (2+3), (4+5), (6+7), (8+9), and 9X. Additional logic states transfer the up and down input pulses to the next higher decade or to the next lower decade. The transfer states are identified as oddX and 9X. The logic transfer states are coupled through diode networks so that the readout will always display the correct number regardless of a transfer state. If the logic has the combination oddX and 9X, the readout will display a 9. The logic symbols used to describe the various conditions are shown in table III.

TABLE III
Logic Symbols.

TRINARY	
OddX	ODD TRANSFER STATE
$\overline{\text{OddX}}$	NOT ODD TRANSFER STATE
Odd	ODD STATE
Even	EVEN STATE
HEXANARY	
(0+1)	ZERO OR ONE
(2+3)	TWO OR THREE
(4+5)	FOUR OR FIVE
(6+7)	SIX OR SEVEN
(8+9)	EIGHT OR NINE
9X	EIGHT OR NINE TRANSFER
$\overline{\text{9X}}$	NOT EIGHT OR NINE TRANSFER
9X	NINE TRANSFER
$\overline{\text{9X}}$	NOT NINE TRANSFER

If the decades are in a 00000 count when a series of up drive pulses are received, the following events occur.

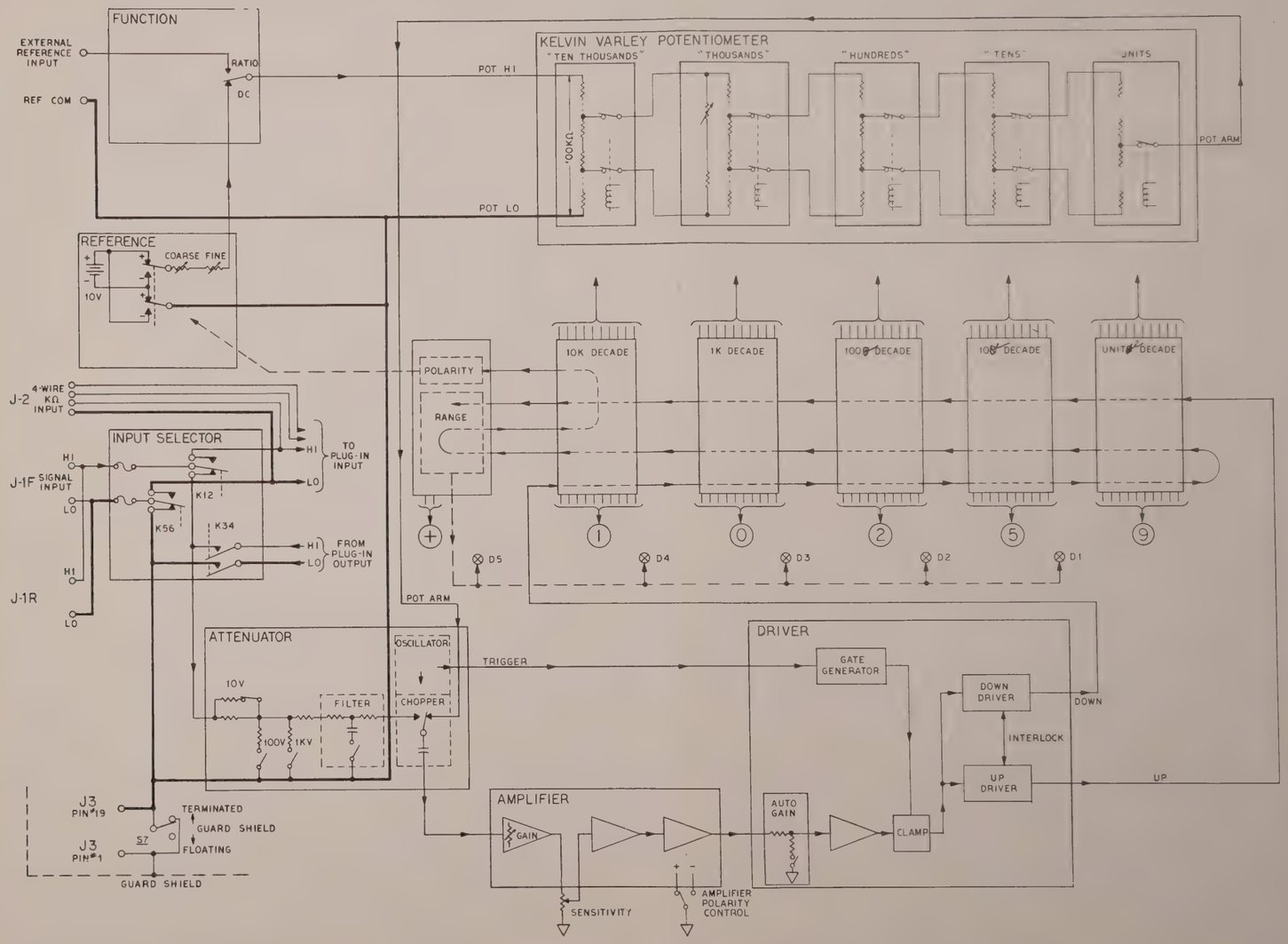


Figure 5-2. Signal Circuits Block Diagram, Schematic 1.

NOTE

In the counting logic of the Series 9000B, 0 is treated as an even number.

The first up drive pulse, applied to the units decade, changes the logic from even to odd and advances the count to 1. The second up pulse changes the logic to odd X, and advances the count to 3. The logic cannot return to even until it gets a down drive pulse, so additional up pulses advance the count to 5, 7, 9, and 9X. As soon as the transfer state is reached, the logic transfers the up signals to the next higher decade, in this case the tens decade.

The counting sequence in the tens decade is identical to the counting sequence in the units decade. The logic counts in odd steps beginning with even to odd to oddX, continuing to 9X. The sequence in the hundreds decade and thousands decade is the same. When the thousands decade reaches the 9X state, the up pulses are directed into the ten thousands decade. Up pulses advance the count of the ten thousands decade in the conventional manner: from 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, and then to 9X. When the ten thousands decade reaches the 9X state, any additional up pulses applied to the decade are directed by logic to the range and polarity board, where the up pulses fire a one-shot. The one-shot output triggers the range counter to advance the instrument to the next higher range. Schematic 2 is a logic diagram of the counting sequence.

Table IV shows the counting sequence for continuous up pulses. The symbol of the dot (.) between the two columns indicates "and".

The trinary determines which of the two numbers in each hexanary number pair is shown on the readout. In the first state shown on the table there is no drive pulse present. The trinary is in the even state, and the hexanary is in the (0+1) state. The number displayed on the readout is 0. The first up count transfers the trinary state to odd. The hexanary state remains in (0+1). The number displayed on the readout is 1. The next up pulse advances the trinary to oddX, and the hexanary to the (2+3) state. The number displayed on the readout is 3. The trinary remains in the transfer state and the hexanary shifts, in order, to the (4+5) state, the (6+7) state, the (8+9) state and the 9X state. When the decade is in the 9X state the A gate transfers the up output to the next higher decade.

TABLE IV
Up Count.

DRIVE	TRINARY STATE	and	HEXANARY STATE	NUMBER DISPLAYED IN READOUT
	Even	.	(0+1)	0
UP	Odd	.	(0+1)	1
UP	OddX	.	(2+3)	3
UP	OddX	.	(4+5)	5
UP	OddX	.	(6+7)	7
UP	OddX	.	(8+9)	9
UP	OddX	.	9X ----┐	9
			Up output to next higher decade.	

Table V shows the four different states possible in the trinary and hexanary. The four conditions are the only conditions that may exist in the unit.

TABLE V
Four Different Stable States Derived From the Trinary and Hexanary.

TRINARY and HEXANARY		
Transfer (X)	.	Transfer (X)
Transfer (X)	.	Not in Transfer ($\bar{X}$)
Not in Transfer ($\bar{X}$)	.	Transfer (X)
Not in Transfer ($\bar{X}$)	.	Not in Transfer ($\bar{X}$)

Down-counting logic on the decades consists of several AND gates and OR gates. The AND gates recognize two simultaneous conditions, and when both conditions exist, produce an output. Down drive pulses, first applied to the ten thousands decade, act upon the most significant decade which is in the transfer state. Down pulses applied to the ten thousands decade are directed simultaneously into AND gates B and E. If the 10K decade is in the 9X state, gate B recognizes the transfer state and the down pulse, and passes the signal through an OR gate to gate F. Gate F recognizes the down signal, and that the 10K decade is not in 0. Gate F output forces the decade to set to 1. If the 10K decade is in a count of any number, but not a transfer state, gate B rejects any down drive input, but gate E accepts the down pulse. The output of gate E is passed to the next lower decade, which is the thousands (1K) decade.

The 1K decade and all the lower decades treat down signals in a different manner than the 10K decade, because the logic is limited to number pairs, and odd-even number sets. A down signal input is directed to gates B and D. If the decade is in the 9X state, gate B passes the down pulse through an OR gate to reset the decade to the number pair (0+1). If the decade is not in the 9X state, the down signal passes through gate D because the input conditions of gate D are satisfied: the decade is not in the 9X state and a down pulse is present. Gate D passes the down signal to gates E and F. If the trinary section is in oddX, the signal passes through gate E to an OR gate. The OR gate forces the trinary section to set to the even stage. If the trinary section is not in oddX, the down signal is rejected by gate E but passed by gate F. The output of gate F is applied to the next lower decade, which is the hundreds decade. The down signals pass through similar logic in the hundreds decade, tens decade, and the units decade until the down pulses finally appear at the output of the F gate of the units decade.

NOTE

Passing the down signal through the decades, starting with the most significant decade first, causes all decades to clear the transfer state. Whenever all transfer states on a decade are cleared, the down signal passes on to the next lower decade. Passing the down signals through the decades in this fashion clears only the transfer states.

The down pulses from gate F of the units decade are connected back into the units decade as reset signals. If the units decade is in the odd logic state, the reset signals pass through the OR gate and force a reset to the even stage. As soon as the decade is in the even stage, the next reset pulse passes through gate G and an OR gate to force a reset to the number pair (0+1). If or as soon as the units decade is in the (0+1) combination, the reset pulses pass through gate C to the next higher decade. The same logical sequence takes place in the tens, hundreds, and thousands decades. When the reset pulses appear at the output of gate C of the 1K decade, they are applied to the 10K decade. On the 10K decade, the reset pulses are directed to an OR gate and gates C and D. If the 10K decade is at any random number the reset pulses pass through the OR gate to gate F. The 10K decade is not at 0, and a reset signal is present, so gate F passes the signal to reset the decade to 1. If or as soon as the decade is in the 1 state, the input conditions of gate D are satisfied and the reset signals pass through gate D to the range and polarity board. On the range and polarity board the reset signals cause the range circuit to reset to the 10V range. If or as soon as the range and polarity board is in the 10V range, or if manual range is selected, the reset signals pass back to the 10K decade, to reset the 10K decade to 0. If or as soon as the 10K decade is in 0 state, the reset pulses pass through gate C to the polarity one-shot on the range and polarity board. When the one-shot fires, the instrument reverses polarity.

Table VI shows the logic states that exist when both the trinary and hexanary are in a transfer state.

TABLE VI

Down Count From Both Transfer States.

DRIVE	TRINARY STATE	and	HEXANARY STATE	NUMBER DISPLAYED IN READOUT
	OddX	.	9X	9
DOWN	OddX	.	(0+1)	1
DOWN	Even	.	(0+1)	0

The trinary determines that the number displayed by the hexanary is odd. Since the hexanary is displaying 9X, the number displayed is 9. The first down pulse sets the hexanary to the (0+1) state, with the trinary remaining in the oddX state. The number displayed in the readout is 1. The next down drive pulse advances the trinary to even; the hexanary remains in the (0+1) state, and the number displayed in the readout is 0.

Table VII shows a down count when the trinary is in a transfer state.

TABLE VII

Down Count From an Odd Transfer State.

DRIVE	TRINARY STATE	HEXANARY STATE	NUMBER DISPLAYED IN READOUT
	OddX	. (6+7)	7
DOWN	Even	. (6+7)	6
DOWN RESET	Even	. (0+1)	0

TABLE VIII

Down Count From a 9X Transfer State.

DRIVE	TRINARY STATE	HEXANARY STATE	NUMBER DISPLAYED IN READOUT
	Odd	. 9X	9
DOWN	Odd	. (0+1)	1
DOWN RESET	Even	. (0+1)	0

TABLE IX

Down Count From No Transfer State.

DRIVE	TRINARY STATE	HEXANARY STATE	NUMBER DISPLAYED IN READOUT
	Odd	. (4+5)	5
DOWN RESET	Even	. (4+5)	4
DOWN RESET	Even	. (0+1)	0

The trinary is in the odd state and the hexanary in the (4+5) state. The number displayed is 5. With neither the trinary nor the hexanary in a transfer state, the next down pulse becomes a down reset which sets the trinary to even; the hexanary remains in the (4+5) state and the number displayed is 4. The next down pulse is also a down reset. The trinary remains in even, the hexanary shifts to the (0+1) state, and the number displayed is 0.

Table X shows a counting sequence with a range change and table XI shows a counting sequence with a polarity change.

TABLE X

Typical Counting Sequence Including a Range Change, Starting at +0.0000 and Going to +23.256.

DRIVE	DVM READING	10K	1K HEX and TRI	100 HEX and TRI	10 HEX and TRI	1 HEX and TRI	COMMENT
	+0.0000	0	(0+1) . Even	(0+1) . Even	(0+1) . Even	(0+1) . Even	
UP	+0.0001	"	" . "	" . "	" . "	" . Odd	
UP	+0.0003	"	" . "	" . "	" . "	(2+3) . OddX	
UP	+0.0005	"	" . "	" . "	" . "	(4+5) . "	
UP	+0.0007	"	" . "	" . "	" . "	(6+7) . "	
UP	+0.0009	"	" . "	" . "	" . "	(8+9) . "	
UP	+0.0019	"	" . "	" . "	" . Odd	9X . "	see note 1
UP	+0.0039	"	" . "	" . "	(2+3) . OddX	" . "	
UP	+0.0059	"	" . "	" . "	(4+5) . "	" . "	
UP	+0.0079	"	" . "	" . "	(6+7) . "	" . "	
UP	+0.0099	"	" . "	" . "	(8+9) . "	" . "	
UP	+0.0199	"	" . "	" . Odd	9X . "	" . "	see note 1
UP	+0.0399	"	" . "	(2+3) . OddX	" . "	" . "	
UP	+0.0599	"	" . "	(4+5) . "	" . "	" . "	
UP	+0.0799	"	" . "	(6+7) . "	" . "	" . "	
UP	+0.0999	"	" . "	(8+9) . "	" . "	" . "	
UP	+0.1999	"	" . Odd	9X . "	" . "	" . "	
UP	+0.3999	"	(2+3) . OddX	" . "	" . "	" . "	
UP	+0.5999	"	(4+5) . "	" . "	" . "	" . "	
UP	+0.7999	"	(6+7) . "	" . "	" . "	" . "	
UP	+0.9999	"	(8+9) . "	" . "	" . "	" . "	
UP	+1.9999	1	9X . "	" . "	" . "	" . "	see note 1
UP	+2.9999	2	" . "	" . "	" . "	" . "	
UP	+3.9999	3	" . "	" . "	" . "	" . "	
UP	+4.9999	4	" . "	" . "	" . "	" . "	
UP	+5.9999	5	" . "	" . "	" . "	" . "	
UP	+6.9999	6	" . "	" . "	" . "	" . "	
UP	+7.9999	7	" . "	" . "	" . "	" . "	
UP	+8.9999	8	" . "	" . "	" . "	" . "	
UP	+9.9999	9	" . "	" . "	" . "	" . "	
UP	+99.999	9X	" . "	" . "	" . "	" . "	see note 2
DWN	+19.999	1	" . "	" . "	" . "	" . "	see note 3
UP	+29.999	2	" . "	" . "	" . "	" . "	
DWN	+21.999	"	(0+1) . "	" . "	" . "	" . "	
UP	+23.999	"	(2+3) . "	" . "	" . "	" . "	
DWN	+22.999	"	(2+3) . Even	" . "	" . "	" . "	see note 4
UP	+23.999	"	" . Odd	" . "	" . "	" . "	
DWN	+23.199	"	" . "	(0+1) . "	" . "	" . "	
UP	+23.299	"	" . "	(2+3) . Even	" . "	" . "	
DWN	+23.219	"	" . "	" . "	(0+1) . "	" . "	
UP	+23.239	"	" . "	" . "	(2+3) . "	" . "	
UP	+23.259	"	" . "	" . "	(4+5) . "	" . "	
DWN	+23.249	"	" . "	" . "	" . Even	" . "	
UP	+23.259	"	" . "	" . "	" . Odd	" . "	see note 4
DWN	+23.251	"	" . "	" . "	" . "	(0+1) . "	
UP	+23.253	"	" . "	" . "	" . "	(2+3) . "	
UP	+23.255	"	" . "	" . "	" . "	(4+5) . "	
UP	+23.257	"	" . "	" . "	" . "	(6+7) . "	
DWN	+23.256	"	" . "	" . "	" . "	" . Even	

NOTE 1. When the hexanary goes into the 9X state, it transfers the up drive pulse to the next higher decade.

NOTE 2. When all the decade states are in the 9X state and the logic receives another up pulse, the DVM will shift to the next higher range if the unit is in auto-range.

NOTE 3. When a down drive pulse is received in the 10K decade, and the 10K decade is in a 9X state, the input conditions set the decade to 1 with one down drive pulse.

NOTE 4. Although the decade was in the number wanted, it must clear the transfer state before down pulses can enter the next lower decade. To do this, the trinary advances from odd to even to oddX. This permits the down pulse to enter the next lower decade.

TABLE XI

Typical Logic Counting Sequence Including a Polarity Change, Starting at +8.9999 and Going to -8.0000.

DRIVE	DVM READING	10K	1K HEX and TRI	100 HEX and TRI	10 HEX and TRI	1 HEX and TRI	COMMENT
	+8.9999	8	9X . OddX	9X . OddX	9X . OddX	9X . OddX	
DWN	+8.1999	"	(0+1) . "	" . "	" . "	" . "	ref table 5-4
DWN	+8.0999	"	" . Even	" . "	" . "	" . "	ref table 5-5
DWN	+8.0199	"	" . "	(0+1) . "	" . "	" . "	
DWN	+8.0099	"	" . "	" . Even	" . "	" . "	see note 1
DWN	+8.0019	"	" . "	" . "	(0+1) . "	" . "	
DWN	+8.0009	"	" . "	" . "	" . Even	" . "	
DWN	+8.0001	"	" . "	" . "	" . "	(0+1) . "	
DWN	+8.0000	"	" . "	" . "	" . "	" . Even	
DWN RST	+1.0000	1	" . "	" . "	" . "	" . "	
DWN RST	+0.0000	0	" . "	" . "	" . "	" . "	
DWN RST	-0.0000	"	" . "	" . "	" . "	" . "	ref page 5-10
UP	-0.0001	"	" . "	" . "	" . "	" . Odd	5-10 "pol.
UP	-0.0003	"	" . "	" . "	" . "	(2+3) . OddX	change"
UP	-0.0005	"	" . "	" . "	" . "	(4+5) . "	
UP	-0.0007	"	" . "	" . "	" . "	(6+7) . "	
UP	-0.0009	"	" . "	" . "	" . "	(8+9) . "	
UP	-0.0019	"	" . "	" . "	" . Odd	9X . "	see note 2
UP	-0.0199	"	" . "	" . Odd	9X . OddX	" . "	see note 2
UP	-0.1999	"	" . Odd	9X . OddX	" . "	" . "	
UP	-1.9999	1	9X . OddX	" . "	" . "	" . "	
UP	-2.9999	2	" . "	" . "	" . "	" . "	
UP	-3.9999	3	" . "	" . "	" . "	" . "	
UP	-4.9999	4	" . "	" . "	" . "	" . "	
UP	-5.9999	5	" . "	" . "	" . "	" . "	
UP	-6.9999	6	" . "	" . "	" . "	" . "	
UP	-7.9999	7	" . "	" . "	" . "	" . "	
UP	-8.9999	8	" . "	" . "	" . "	" . "	conventional
DWN	-8.1999	"	(0+1) . "	" . "	" . "	" . "	counting
DWN	-8.0999	"	" . Even	" . "	" . "	" . "	for 10K
DWN	-8.0199	"	" . "	(0+1) . "	" . "	" . "	
DWN	-8.0099	"	" . "	" . Even	" . "	" . "	
DWN	-8.0019	"	" . "	" . "	(0+1) . "	" . "	
DWN	-8.0009	"	" . "	" . "	" . Even	" . "	
DWN	-8.0001	"	" . "	" . "	" . "	(0+1) . "	
DWN	-8.0000	"	" . "	" . "	" . "	" . Even	

NOTE 1. The down pulses have cleared all of the transfer states starting with the most significant decade, which in this case was the 1K decade, and ending with the least significant decade. Since the logic is still receiving down pulses, the DVM readout will start setting to 0, starting with the units decade and continuing to the next higher decade until all the decades are in 0. Since the units, tens, hundreds and thousands decades are already in 0, the pulse will go directly to the 10K decade.

NOTE 2. When a decade is on (8+9) and receives another up pulse, two states will change. These are: the hexanary in the decade displaying the 9 will change to 9X and the trinary in the next higher decade will step to odd. Thus, in the counting sequence the units will now be 9X and still display a 9 and the tens decade will display a 1. The tens, hundreds, and thousands decades will count and pass on the up pulses in the same manner.

SIGNAL INPUT CONNECTORS (Schematic 3)

The front panel signal input connector J1F, the rear panel 4 wire KΩ input J2, a portion of J3 (programming connector), the guard shield terminating switch S7, and portions of J10B and J10A are shown in Schematic 3. Signal input high, on pin 1 of J1F, is connected through a coax in parallel to pin 1 of J1R. From J1R it is connected through a coax to the input selector; the shield of the coax is used for the signal low connection. Two fuses are provided in the signal low and signal high input.

If the DVM is operated as a ratiometer, the external reference is connected to pin 4 of J1F or J1R, and is directed to the function board where a relay provides selection of the external reference. The external reference is connected to the potentiometer high input. (See Signal Circuit Block Diagram.) To reduce the effects of current sampling, a separate connection, pin 5 of J1F or J1R, is provided for the external reference common (low). The external reference common is internally connected to signal low (DVM common). The input signal is directed to the input selector, where it is switched to the attenuator of the DVM or the input circuit of the plug-in unit. If the plug-in unit is used, the output from the plug-in is returned to the input selector, where it is connected to the attenuator of the DVM. The DVM circuits are completely enclosed in a guard shield which is isolated from signal circuits and power line ground. Under normal conditions, the guard shield is terminated to DVM circuit common through a slide switch on the rear panel (S7). In the TERMINATED position the DVM guard shield is connected to DVM circuit common. If the guard shield is driven from the signal source, the guard shield terminating switch is moved to the FLOATING position.

If the guard shield is not terminated to the DVM common by S7, it must be terminated externally at the signal source (signal low). Two pins in the programming connector J3 (pin 1 and 19) are provided to allow this connection to be programmed.

Rear panel connector J2 is provided for a special input cable for 4 wire KΩ measurements. This cable provides Kelvin clips and is used in connection with Cimron Model 6911B 4 wire ohms converter. Pin numbers 1, 2, 3 and 4 of J2 are connected directly into J10A. J10A is one of the receptacles for the plug-in unit. For extremely low level measurements, the input connection of J2 can be used to bypass the input selector entirely and feed the input signal from J2 into the plug-in unit. For this reason, the plug-in units have the signal input connections paralleled from J10B to J10A. For more detail, the schematics of the various plug-in units should be investigated.

INPUT CABLE ASSEMBLY (Reference figure 5-3)

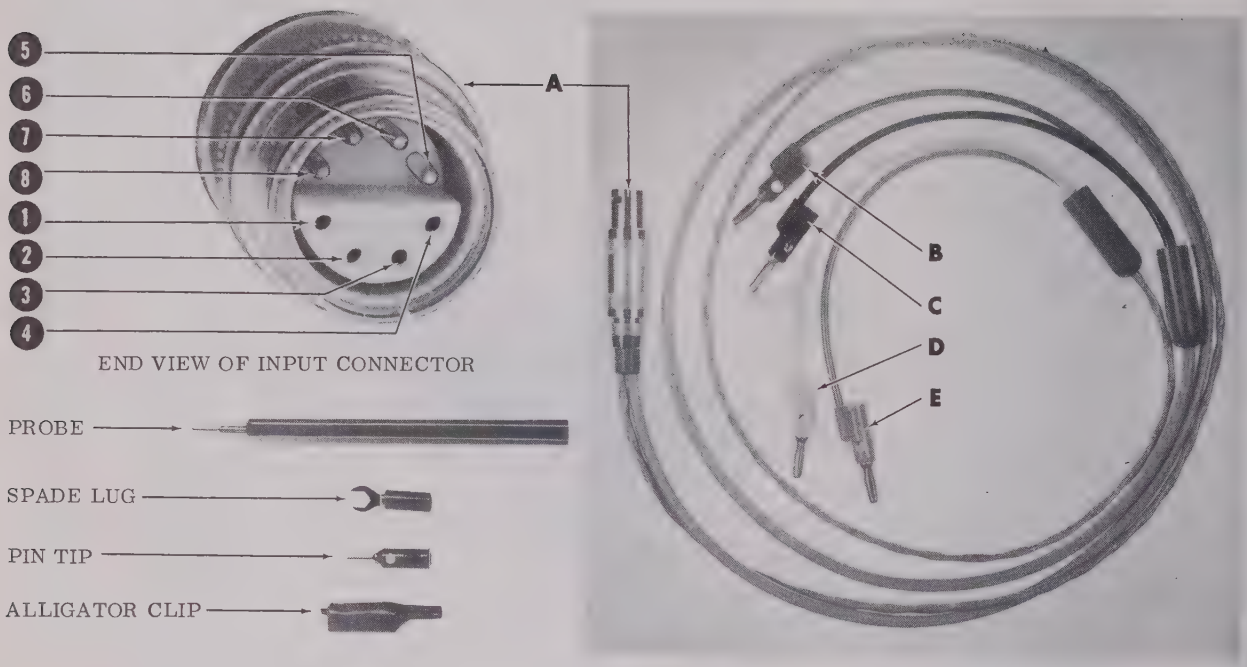
The input cable Cimron P.N. 90-5000-1 consists of an input connector (A) and four leads. These leads are identified in figure 5-3.

B - Red lead connected to pin 1 (Input Signal High)
C - Black lead connected to pin 3 (Input Signal Low)
D - Yellow lead connected to pin 4 (Plus or Minus External Reference Input)
E - Blue lead connected to pin 5 (External Reference Common)

Each lead has a banana plug connector. Each is identified by a distinctive color. Alligator clip adapters are supplied with the standard cable. These adapters are constructed with gold plating for low level measurement applications. These adapters are identified as follows:

Red Alligator Clip	-	Cimron P.N. 2-04711-2
Black Alligator Clip	-	Cimron P.N. 2-04711-0
Yellow Alligator Clip	-	Cimron P.N. 2-04711-4
Blue Alligator Clip	-	Cimron P.N. 2-04711-6

Cimron has three other adapter connectors which are not supplied with the standard cable but may be purchased. These are shown in figure 5-3 as Probe Pin Tip and Spade Lug. These adapters are identified as:



END VIEW OF INPUT CONNECTOR

ADAPTORS FOR B, C, D, E

INPUT CABLE ASSEMBLY WITH BANANA PLUGS

Figure 5-3. Input Cable Assembly.

Probe	Black	Cimron P.N. 2-04730-0
	Red	Cimron P.N. 2-04730-2
Pin Tip	Black	Cimron P.N. 2-04725-0
	Red	Cimron P.N. 2-04725-2
Spade Lug	Black	Cimron P.N. 2-04720-0
	Red	Cimron P.N. 2-04720-2

INPUT SELECTOR ASSEMBLY (Schematic 4)

The input selector used in 9000B series instruments is shown on schematic 4.

Relays K12 and K56 are printed circuit relays. Reed relays K3 and K4 are always operated in parallel and for simplicity are identified as K34. All relays are operated from the +17V supply. Relays are energized by connecting the coil terminal to circuit common through diode networks on the function board or diode networks in the plug-in accessory, if used. The relays are shown in the DC function position; K12 is energized through a diode network on the function board in the DVM. Input signal high has a fusing jumper provided at the input, for the protection of the internal circuitry against accidental misuse of the instrument. To obtain a low thermal characteristic, the fuse consists of a short piece of single strand 34 gage wire. From the fuse the signal is connected to the arm of K12. In DC function, K12 is energized as shown in the schematic, so that a signal is connected through the closed contacts directly to a terminal, identified as AT HI, which is attenuator high in the DVM. Input signal low is connected through a fuse to the arm of K56. In DC function K56 is not energized. The signal is connected through the normally closed contacts to the terminal AT LO which is attenuator low in the DVM.

When the DVM is operated with a plug-in module inserted into the accessory compartment, the proper accessory function is selected on the DVM front panel. The contact closures on the input selector are commanded by the plug-in assembly. K56 and K34 are energized. The input signal high is connected through the fuse to the arm of K12. K12 is not energized in accessory function, therefore the signal passes through the normally closed contacts to the terminal identified as A1. A1 is the input signal high connection to the plug-in unit. Input signal low is connected through the input fuse to the arm of K56. K56 is energized. The signal is connected through the normally open contacts, which are now closed, to the terminal identified as A14. A14 is the input signal low connection to the plug-in unit. The output high from the plug-in unit comes to terminal B2. From B2 it is connected through closed switch S1, to attenuator high (AT HI). The output low from the plug-in unit comes to terminal B14, and is applied to terminal AT LO through S2.

The input selector board is mounted underneath a mounting shield in the right rear corner of the DVM directly behind the plug-in accessory compartment. The two input fuses are exposed however, so that in case it should be necessary, the fuse can be replaced without unnecessary disassembly.

ATTENUATOR ASSEMBLY (Schematic 5)

This assembly contains the attenuator, input filter, and chopper network which compares the input signal with the bridge output. Ranging is accomplished by reed relays. There are three relays in the attenuator and one additional relay for a filter. The relays are driven from the +17V supply. They are energized by terminating the coil terminal to circuit common through transistor switches on the range and polarity board. The filter relay is operated by contact closure at the filter switch on the front panel. Signal high and signal low are connected to their respective pins from the input selector. Signal low is terminated to DVM circuit common. Signal high goes directly into the resistive attenuator network. The contact closures for the various ranges are as follows: on the 10V range, switch 101 is closed, switch 102 and 103 are open; on the 100V range switch 101 and 102 are open and switch 103 is closed; on the 1000V range switch 101 and 103 are open while switch 102 is closed. Across the attenuator output are a pair of neons, DS101 and DS102, for over-voltage protection. From that point the signal is fed to a twin T network. This network has a very sharp response at 60 cps. The detail characteristics are shown in figure 4-8. At the twin T output a pair of capacitors, C103 and C104, are connected to the filter switch, S104. The normal mode attenuation in both positions, FILTER IN and FILTER OUT, is shown in figure 4-8. From the filter output the signal is connected into the chopper circuit. The chopper is a solid state modulator which continuously compares the input signal with the output of the precision potentiometer (pot arm). The output of the chopper is connected through C108 to the amplifier. A field effect transistor, Q101, was selected for its very high input impedance and low noise characteristics. The output is taken from its source and applied to the amplifier assembly input which is TP1. R111, R112, and C105 are a filter network which reduces the effects of high frequency transients. C111 is a 10MF capacitor connected between the guard shield and DVM circuit common. It provides a low AC impedance between guard shield and circuit common if the guard shield is driven from an external source, and if there is a high unbalance in the input low. Under normal operation, this capacitor is short circuited by the input guard terminating switch which is mounted on the rear panel of the DVM.

The chopper, shown in the schematic as a block, is mounted in a 7-pin socket on the attenuator board. It is a completely molded assembly with an internal oscillator which drives the chopper and provides a trigger pulse output to synchronize the gate generator on the driver board. The chopper operates from the +230V supply.

AMPLIFIER ASSEMBLY (Schematic 6)

The amplifier assembly is separated into three sections, a preamplifier, an intermediate amplifier and an output amplifier. The output of each section is identified by TP2, TP3 and TP4. There is a regulator which supplies +12V(Q211), a second regulator which supplies +8.2V for the preamplifier (CR205), another regulator which supplies a regulated -12V (Q209) and a -8.2V regulator for the preamplifier (CR206). The input signal is connected from the attenuator output to the input of the amplifier (shown as IN). The signal goes to test point number 1 (TP1).

From TP1, the signal is applied to a differential pair consisting of Q203 and Q204. From the collector of Q203 the signal is coupled into the base of the emitter follower Q205, Zener diode CR204, in the emitter circuit of Q205, adjusts the DC level of the output signal. The preamplifier output at TP2 is taken from the arm of gain potentiometer R209. The gain of the input preamplifier, from TP1 to TP2, is approximately twenty db. All voltages shown in this schematic are typical but by no means exact. For example, looking at the collectors of the differential pair Q203 and Q204, both collectors are shown as +5V. However, if one collector should measure +6V and the other collector +4V, no malfunction is indicated. On the other hand if one collector is saturated, approximately 0V, and the other is cutoff, approximately 8V, a malfunction is definitely indicated.

From TP2 the signal is coupled through a coupling capacitor C204 into the sensitivity circuit. On the schematic, the sensitivity circuit is shown as a potentiometer mounted on the front panel identified as SENSITIVITY.

From the arm of the potentiometer the signal is fed into the intermediate amplifier consisting of a differential pair Q206 and Q207, the emitter follower Q208 and the amplifier Q210. From the collector of Q210, feedback is taken through R216 and C207 to the base of Q206. The frequency response is shaped by the RC network R214, R215, R216, C206 and C207. The frequency response is peaked at approximately 120 cps. The net gain of the amplifier, TP2 to TP3, is approximately 26 db.

From TP3 the signal is coupled through C210 to the output amplifier, which consists of a differential pair, Q213 and Q214, and emitter follower Q216. Test point 4 (TP4) is in the emitter circuit of Q216. The gain between test points TP3 and TP4 is approxi- 20 db. Two transistor switches, Q212 and Q215, are included in the output amplifier circuit for polarity switching.

In negative polarity (-), the base of Q212 is held at circuit common through resistor R228. The emitter of Q212 is also at circuit common, holding the switch back-biased. Control voltage from the range and polarity board is applied to the transistor base through the pin marked - (minus), and resistor R229. The control voltage is +16V for minus polarity, and 0V for positive polarity. When the control voltage is at +16V, R229 overcomes the reverse bias on Q212, and the transistor saturates. In minus polarity, the control voltage to the base of Q215 is 0V, and Q215 is reverse biased. When Q212 saturates, it provides AC circuit common through R233 to the base of Q213. Signal flow, therefore, is from TP3 through C210 and R232 to the base of Q214. The output characteristic of the amplifier is non-inverting.

In positive polarity (+), the control resistor of Q212 is returned to 0V and the control resistor of Q215 is returned to +16V. Q212 is off and Q215 is saturated, providing AC circuit common to the base of Q214. The signal flows from TP3 through C210 and R231 into the base of Q213. From there the signal is emitter coupled into Q214 which now has a grounded base. From the collector of Q214, the signal is coupled into the output emitter follower Q216. The output characteristic of the amplifier is inverting. The plus and minus control voltages are obtained from the polarity binary on the range and polarity board.

DRIVER ASSEMBLY (Schematic 7)

The output of the amplifier assembly is applied to the driver assembly through series resistors R1 and R2. Up and down drive pulses for decade switching are developed in the driver assembly. For simplification the schematic of the driver assembly has been divided into blocks, identified as auto gain, amplifier, clamp, gate generator, down driver, and up driver.

In DC mode the auto gain circuit maintains the digital voltmeter at a constant sensitivity level by changing attenuator circuits to compensate for the effects of noise. Since noise pickup is greater at either end of the precision potentiometer than in the middle, properly scaled attenuator circuits are inserted in the driver assembly input by the 10K decade decimal output circuits.

In DC function, when the 10K decade is in a zero state, the attenuator circuit consists of C1, R7, and R6, in series, between the signal input and circuit common. When the input signal causes a count of 1 in the 10K decade, the input at diode CR3 drops from approximately 100 VDC to approximately 1 VDC, biasing transistor Q2 into conduction. Resistor R10 is inserted in the attenuator circuit, in parallel with R6. When the count in the 10K decade changes from 1, Q2 is cut off, removing R10 from the attenuator circuit. A count of 2 or 3 in the 10K decade causes transistor Q3 to conduct, placing resistor R14 in parallel with R6. A count of 4, 5, or 6 in the 10K decade causes transistor Q4 to conduct and put resistor R18 in parallel with R6. A count of 7, 8, or 9 in the 10K decade causes transistor Q5 to conduct and put R22 in parallel with R6.

Transistor Q1 is biased into conduction when the instrument is in AC or AC RATIO mode. When Q1 conducts resistor R3 is in parallel with R6 and R7. The reduction in instrument sensitivity is necessary to compensate for the noise and instability usually present in any AC signal.

The attenuated signal from the auto gain circuit is applied to the base of emitter follower transistor Q6 in the amplifier circuit. Test point 12 (TP12) is in the emitter circuit of Q6. The output of the emitter follower is applied to the base of transistor Q7. Diodes CR12 and CR13 provide signal limiting to prevent large error signals from exceeding the dynamic range of the amplifier. Transistors Q7 and Q8 form a differential amplifier. The amplifier output is passed through complementary emitter follower transistors Q9 and Q10. The output of the emitter follower is applied to test point 13 (TP13) in the clamp circuit. The gain between TP12 and TP13 is approximately 20 db.

Clamp transistor Q11 is driven by the gate generator to demodulate the amplifier output. Biased at saturation by resistor R35, the transistor applies circuit common potential at TP13, completely masking the amplifier output. Positive pulses from the gate generator turn transistor Q11 off during the gate period, permitting the amplifier output to reach the driver circuits.

The gate generator consists of a monostable (transistors Q16 and Q17), transistor switch Q18, and output transistor Q19. In the stable state, Q16 conducts, Q17 is cut off. A positive pulse from the chopper oscillator, applied at the junction of resistor R56 and diode CR19, triggers Q17 into conduction. Q16 is cut off. The positive signal from the collector of Q16 is applied to the base of transistor Q18 through a delay network of resistor R55 and capacitor C12. Q18 is normally off. The signal, delayed by approximately 250 microseconds, triggers Q18 into conduction. Transistor Q19, also normally cut off, is drawn into conduction by the collector of Q18. A positive gate pulse of approximately two milliseconds duration is produced at the collector of Q19. The gate pulse is applied to the clamp through resistor R65. The junction of resistors R64 and R65 is connected to a pin connector of the driver assembly board. Circuit common, applied to the connector pin through the PRINT CONTROL or POWER switch, disables the gate in HOLD or STANDBY conditions.

The demodulated amplifier output signal at TP13 is direct-coupled in parallel to the up and down driver circuits through resistors R36 and R37. The up driver and down driver circuits are complementary monostables. PNP transistors are used in the up driver; NPN transistors are used in the down driver. The down driver output is through a PNP transistor to obtain proper signal inversion. The up driver circuit responds to positive input signals from the clamp circuit. The down driver responds to negative input signals from the clamp circuit. The driver circuits are basically similar; only the up driver is described in detail.

Regulated -12 VDC collector supply voltage for the up driver circuit is provided from the -18 VDC supply through zener diode CR23 and filtered by resistor R66 and capacitor C13. Transistors Q20 and Q22 form a monostable with Q20 saturated and Q22 cut off in the stable state. Transistor Q21 provides an interlock from the down driver, conducting only when the down driver is fired. Q20 receives base current through a resistive and zener diode network consisting of resistors R68, R39, BALANCE adjustment potentiometer R38 and zener diode CR14. When the error signal from the clamp circuit exceeds one volt positive, Q20 is cut off, causing Q22 to conduct. The up drive pulse is taken from the collector of Q22 through capacitors C16 and C17 in parallel, and applied to pin connectors identified as Up 1 and Up 2. Test point 15 (TP15) is in the Up 2 circuit. Up 1 output is connected to the digital voltmeter logic. Up 2 output is an input to the null detector in the print control assembly.

Q21 is the interlock transistor in the up driver. Q13 is the interlock transistor in the down driver. Both transistors are biased off. When Q22 of the up driver is conducting, circuit common potential at the transistor collector is applied through resistor R71 to the base of Q13 in the down driver. Q13 conducts, holding the base of transistor Q14 at circuit common potential for as long as Q22 is conducting. The down driver cannot respond to an input signal while the up driver is generating a pulse. Q21 in the up driver is controlled in a similar manner to prevent an up pulse while a down pulse is being generated. Down 1 output is connected to the digital voltmeter logic. Down 2 output is an input to the null detector in the print control assembly. Both up and down pulses are positive pulses of approximately two milliseconds duration.

The BALANCE adjustment potentiometer R38 balances the bias of both driver circuit input transistors simultaneously to provide equal response. Voltages shown on the schematic refer to normally off, or no-signal, condition.

DECADE

The decade counter assemblies control the precision potentiometer switching relays and the readout display indicators. Decade assemblies are used as units, tens, hundreds, and thousands decades. A 10K decade assembly is used in the ten thousand counting circuit.

Each decade assembly consists of a three-stage trinary counter, a six-stage hexanary counter, logic circuits and ten output driver transistors. Silicon Controlled Switches (SCS) are used in the ring counter stages.

TRINARY DESCRIPTION

The trinary counter is a ring counter with three stable states, Even, Odd, and Odd Transfer (OddX). SCS Q5 is on during the Even state, Q6 is on during the Odd state, and Q7 is on during the OddX state.

In the Even state transistor Q1 is back-biased by approximately +12V DC applied to the emitter. Transistor Q4 is saturated, providing circuit common to the emitter of transistor Q3 and the base of transistor Q21. Q5 holds transistor Q28 in conduction. (Q28 receives collector supply through one of the driver transistors in the hexanary counter.) Transistor Q3 is biased off. A positive-going up pulse

input does not trigger Q1, but does trigger Q3 through the RC network R2, C1. Q3 momentarily saturates, applying circuit common to the anode of Q5. Q5 is shut off. The charge on coupling capacitor C5 triggers Q6 on, setting the trinary counter in the Odd state. A down pulse input does not affect the trinary counter in the Even state.

Transistor Q28 is cut off, however, and transistor Q30 is biased into conduction. An up pulse input triggers Q3 into momentary saturation, turning Q6 off. The charge on coupling capacitor C7 triggers Q7 on, setting the trinary counter in the OddX state. A down pulse does not affect the trinary counter in the Odd state.

In the OddX state the anode gate of Q7 holds the emitter of Q1 at circuit common. Transistor Q4 is biased off, cutting off emitter supply to Q3 and back-biasing Q21. Transistor Q3 cannot respond to additional up pulses, and the trinary counter remains in the OddX state. The change from Odd state to OddX state is accomplished so rapidly that transistor Q1 responds to the same up pulse which causes the trinary change of state. A down pulse can reset the trinary from the OddX state to the Even state through the down pulse logic gates.

HEXANARY DESCRIPTION

The hexanary counter consists of six Silicon Controlled Switches (SCS) arranged as a six-stage ring counter, ten driver transistors, and associated control transistors. Each SCS controls the base current of two driver transistors associated with a number pair. SCS Q13 controls the 0+1 (zero or one) drivers, transistors Q27 and Q29. SCS Q14 controls the 2+3 drivers, transistors Q31 and Q32. Additional stages of the counter are similar. SCS Q17 controls the 8+9 drivers. SCS Q18 is the 9X stage, which also controls the 8+9 pair and applies circuit common to the emitter of Q19 and the 9X control line. When Q18 is on the hexanary is in the 9X state. When Q18 is off, the hexanary is in the $\overline{9X}$ (not 9X) state. The 0, 2, 4, 6, and 8 drivers receive collector supply through transistor Q28, which conducts when the trinary counter is in the Even state. The 1, 3, 5, 7, and 9 drivers receive collector supply through transistor Q30, which conducts when the trinary counter is in the Odd or OddX states. In the $\overline{9X}$ (not 9X) state of the hexanary counter, transistor Q12 is saturated, supplying emitter current to transistors Q9 and Q11. Q11 is biased off. Each up pulse passed by the gate composed of Q1 and Q2 is applied to the base of Q11, causing the transistor to momentarily saturate. Each time Q11 saturates, the ring counter advances one count. A down pulse applied to the decade assembly while the hexanary is in the $\overline{9X}$ state does not affect the counter. The trinary, however, changes from Odd to Even, causing Q30 to cut off and Q28 to conduct. The display indicator changes from an odd number to the next lower even number.

In the 9X state of the hexanary counter SCS Q18 is on. Transistor Q12 is back-biased. Transistor Q11 cannot respond to additional up pulses, which are passed to the next higher decade. A down pulse in the 9X state, however, causes the counter to reset to the 0+1 stage, in the $\overline{9X}$ state, with SCS Q13 on and all other stages of the ring counter off.

LOGIC GATE DESCRIPTION

Transistors Q1 and Q2 form a two-input AND gate, designated as Gate H in the block diagram shown in Schematic 2. The emitter of Q1 is connected to the anode gate of SCS Q7 in the trinary counter, which is approximately +12V DC in the Even and Odd states, and circuit common in the OddX state. The base of Q1 is biased at circuit common. Up pulse inputs to the base of Q1 trigger the transistor only when the trinary counter is in the OddX state. Q1 triggers Q2, which is normally off. A positive pulse is generated at the collector of Q2 which has the same amplitude and duration as the up pulse input.

Transistors Q19 and Q20 form a similar AND gate, designated as Gate A in the block diagram shown in Schematic 2. The emitter of Q19 is connected to the anode gate of SCS Q18, which conducts only in the hexanary 9X state. The emitter of Q19 is biased at approximately +12V DC except in the 9X state, when Q18 holds the 9X line at circuit common. Up pulses applied to Q19, when the hexanary is in the 9X state, trigger the transistor, which in turn triggers Q20. A positive pulse, of the same amplitude and duration as the up pulse input, is generated at the collector of Q20, and passed to the next higher decade.

AND Gate B consists of Q8, with the 9X input applied to the emitter and the down pulse input applied to the base. When the hexanary is in the $\overline{9X}$ (not 9X) state the emitter of Q8 is biased at +12V DC by the 9X line, holding the transistor back-biased. When the hexanary is in the 9X state SCS Q18 is conducting, and the 9X line is at circuit common. In the 9X state, a down pulse at the base of Q8 triggers the transistor, which turns SCS Q13 on, through OR gate CR3. Q13 forces Q18 off, and the hexanary counter changes to the $\overline{9X}$ (not 9X) state and the 0+1 stage.

AND Gate D consists of transistors Q9 and Q10. The $\overline{9X}$ (not 9X) input is applied to the emitter of Q9; the down pulse input is applied to the base of Q9. The emitter of Q9 is biased at +12V DC when the hexanary is in the 9X state. The collector of Q9, which is directly connected to the base of Q10, is at +17V DC. Both transistors are back-biased and off. In the $\overline{9X}$ (not 9X) state the emitter of Q9 is biased at circuit common through the anode gate of whichever Silicon Controlled Switch is conducting. A down pulse at the base of Q9 triggers the transistor into conduction, triggering Q10. Q10 conducts, drawing collector supply through either Q21 or Q22. A positive pulse, with the same amplitude and duration as the down pulse input, is generated at the collector of Q10.

AND Gate E consists of transistor Q22. The output of Gate D is directly connected to the emitter of Q22, the OddX input is applied to the base of the transistor. Q22 is back-biased by +17V DC at the base input when the trinary is in the Even or Odd state, and is biased at circuit common when the trinary is in the OddX state. A positive down pulse from gate D (Q9 and Q10), applied to the emitter of Q22, causes the transistor to conduct when the trinary is in the OddX state. A positive pulse of the same amplitude and duration as the input pulse appears at the collector. The pulse from the collector of Q22 is applied to the base of OR gate Q26. The collector of Q26 becomes circuit common potential. Circuit common, applied to the cathode gate of SCS Q5, resets the trinary to Even.

AND Gate F consists of Q21. The output of Gate D is directly connected to the emitter of Q21. The $\overline{OddX}$ (not OddX) input is applied to the base of Q21, which is held at +17V DC when the trinary counter is in the OddX state. Pulses applied to the emitter of Q21 by gate D (Q9 and Q10) do not trigger the transistor when the trinary counter is in the OddX state. When the trinary counter is in the Even or Odd state the base of Q21 is biased at circuit common. A positive down pulse from gate D, applied to the emitter of Q21, triggers the transistor into conduction. A positive pulse of the same amplitude and duration as the input pulse is generated at the collector of Q21, and passed to the next lower decade. In the units decade the output of Q21 becomes a reset pulse applied to AND gate G and OR gate Q26.

AND Gate G consists of transistor Q25. The Even input is applied to the emitter of Q25; the reset input is applied to the transistor base. The emitter of Q25 is connected to the anode gate of Q5, the Even stage of the trinary counter. Q25 is back-biased when Q5 is off (Odd or OddX states). In the Even state the emitter of Q25 is biased at circuit common. A reset pulse triggers the transistor into conduction. The collector of Q25 applies circuit common through diode CR7 and OR gate CR3 to the cathode of SCS Q13 in the hexanary counter. The circuit common pulse causes Q13 to turn on, setting the hexanary counter to 0. The output of Q25 is also applied to AND gate C.

AND Gate C is composed of Transistors Q23 and Q24. The Gate G input is applied to the base of Q23, the 0+1 input is applied to the base of Q24. When Gate G is off (no reset pulse) the base of Q23 is biased at +17V DC. The collector of Q23 is directly connected to the emitter of Q24. The base of Q24 is connected to the anode gate of SCS Q13, which is at +12V DC when Q13 is off. When the hexanary counter is in the 0+1 stage, Q13 is on, and the base of Q24 is at circuit common. A reset pulse from Gate G (Q25) triggers Q23. The collector of Q23 applies +8V DC to the emitter of Q24. If the base of Q24 is at circuit common, the transistor conducts, producing a positive pulse at the collector circuit. The output pulse, of the same amplitude and duration as the input reset pulse, is passed to the next higher decade.

DECADE LOGIC SEQUENCE — UP PULSES
(Schematic 2)

The trinary counter of a decade is in the Even state and the hexanary counter is in the $\overline{9X}$, 0+1 condition when the indicator controlled by the decade is displaying a zero.

An up pulse, applied to the UP IN terminal of the decade assembly, is directed through R1 to the input of Gate H and through R2 to the base of Q3. Gate H is inhibited in the trinary Even state, and therefore ignores the input signal. Q3, however, becomes momentarily saturated, advancing the trinary to the Odd state. The indicator display changes from 0 to 1.

The next up pulse is applied to the Gate H input and also saturates Q3. The trinary advances to the OddX state. Instantaneously, as SCS Q7 is turned on, the voltage at the emitter of Q1 drops to circuit common, enabling Gate H. The up pulse, still present at the base of Q1, is passed through Gate H and directed to the input of Gate A through R58, and to the base of Q11 through R29 and C9. Gate A, inhibited in the hexanary $\overline{9X}$ state, ignores the input. Q11 becomes momentarily saturated, advancing the hexanary to the 2+3 stage. The indicator display changes from 1 to 2. Up pulse time duration is sufficient for the same pulse to advance the trinary to the OddX state and advance the hexanary to the 2+3 stage. Successive up pulses pass directly through Gate H to advance the hexanary stage by stage to the 8+9 stage.

When the hexanary is in the 8+9 stage, the next up pulse advances the hexanary to the 9X state. SCS Q18 is turned on, enabling Gate A, which passes the same up pulse to the next higher decade. SCS Q18 holds transistor Q11 back-biased through transistor Q12. Additional up pulses passed by Gate H are rejected by Q11, but are passed to the next higher decade through Gate A. The decade remains stable in the OddX, 9X state. The indicator displays a 9.

DECADE LOGIC SEQUENCE — DOWN PULSES
(Schematic 2)

Down pulses at the DOWN IN terminal of the decade assembly are applied to Gate B and Gate D. If the hexanary is in the 9X state, Gate B is enabled by the circuit common potential at the emitter of transistor Q8, and Gate D is inhibited by a positive potential at the emitter of transistor Q9. The down pulse is passed through Gate B and OR Gate CR3 to the cathode gate of SCS Q13. Q13 turns on, setting the hexanary counter in the 0+1 stage and the $\overline{9X}$ state. Gate B is inhibited in the $\overline{9X}$ state and Gate D is enabled. The display indicator changes from 9 to 1. The next down pulse is passed through Gate D to Gates E and F.

If the decade hexanary counter is in the $\overline{9X}$ state and any random number pair stage, Gate D is enabled by the $\overline{9X}$ input, circuit common at the emitter of transistor Q9. Gate B is inhibited by a positive potential at the emitter of transistor Q8. The down pulse input is passed through Gate D and applied to Gate E and Gate F.

If the trinary is in the OddX state Gate E is enabled by circuit common at the base of transistor Q22, and Gate F inhibited by a positive potential on the base of Q21. A down pulse from Gate D is passed through Gate E. The positive pulse output of Gate E, applied to the base of OR Gate transistor Q26, causes the transistor to conduct. Circuit common at the

collector of Q26 is applied to the junction of resistor R15 and the cathode gate of SCS Q5. Q5 turns on, setting the trinary to the even stage, and turning off SCS Q7. Gate F becomes enabled and Gate E becomes inhibited. The display indicator changes from an odd number to the next lower even number.

If the trinary is in the Even state Gate E is inhibited and Gate F is enabled by circuit common at the base of Q21. A down pulse from Gate D is passed through Gate F to the DOWN OUT terminal of the decade assembly. In the units decade, a down pulse passed through Gate F becomes a reset input to the RESET IN terminal of the units decade assembly.

DECADE LOGIC SEQUENCE — RESET

A reset input to the RESET IN terminal of the decade assembly is applied to Gate G and OR Gate Q26. The input pulse, applied to the base of Q26, triggers the transistor into conduction. Circuit common from the collector of Q26 is applied to the junction of resistor R15 and the cathode gate of SCS Q5. Q5 turns on, and turns SCS Q7 off, setting the trinary counter at Even. If the trinary is in the Even state, or after it has set to Even, Gate G transfers the reset signal through OR gate CR3 to the cathode gate of SCS Q13. Q13 turns on and turns off any other hexanary stage, setting the hexanary to the 0+1 stage. The readout indicator displays a zero.

If the hexanary is in the 1+0 stage, or after it has been set to 0+1, Gate C transfers the reset pulse to the next higher decade. The connection between the anode gate of SCS Q13 and the base of transistor Q24 causes Gate C to ignore the reset pulse while the hexanary is changing state. A reset pulse which resets the hexanary counter cannot be transferred through a gate, to prevent one pulse from accomplishing two reset functions simultaneously.

10K DECADE (Schematic 9)

The 10K decade consists of an eleven stage Silicon Controlled Switch ring counter, and all necessary control gating. The ring counter provides ten decimal outputs from 0 to 9. The eleventh stage is the 9X stage.

UP SIGNAL OPERATION

In the $\overline{9X}$ state transistor Q12 is saturated, providing emitter supply for transistor Q11. An input up pulse momentarily saturates Q11, applying a circuit common pulse to the ring counter +8V DC supply line. The Silicon Controlled Switch which is on (for any number 0 through 9) is turned off, passing a positive trigger through the coupling capacitor to the next higher stage, which turns on. If the up pulse causes the 9X stage to be turned on, Gate A, which consists of transistors Q8 and Q9, becomes enabled. The same up pulse which causes the ring counter to advance to 9X is passed through Gate A as an Up Range signal to the Range and Polarity Assembly. In the 9X state transistor Q12 is back-biased, preventing transistor Q12 from responding to any further up pulses, which are passed directly through Gate A.

DOWN SIGNAL OPERATION

In the $\overline{9X}$ state transistor Q12 is saturated, providing emitter supply to transistor Q2 of Gate E. Transistor Q3, also part of Gate E, is biased off by the collector supply of Q2. Transistor Q1, which forms Gate B, is back-biased by the positive potential at the anode gate of the 9X stage, SCS Q23. Down pulse inputs are applied to the bases of Q1 and Q2. Q1 cannot respond. Q2 conducts, triggering Q3, which produces a positive pulse of the same duration and amplitude as the input pulse. The down pulse is transferred directly to the next lower decade.

In the 9X state transistor Q12 is back-biased, inhibiting Gate E through the emitter of transistor Q2. Gate B is enabled through circuit common, applied to the emitter of transistor Q1 by the anode gate of SCS Q23. A down pulse input is rejected by Gate E, and passed by Gate B. The inverted pulse is passed through OR Gate CR3 to trigger the 1 stage, SCS Q14. Gate F is composed of the coupling circuit between

the 0 stage, SCS Q13, and the cathode gate of SCS Q14. When SCS Q14 turns on, Q23 is turned off, inhibiting Gate B and enabling Gate E. Further down pulses are passed through Gate E to the next lower decade.

RESET OPERATION

Reset pulse inputs are applied to transistor Q7, which is normally off. Q7 applies an inverted pulse to transistor Q5, and through OR Gate CR3 to the cathode gate of 1 stage SCS Q14. If the ring counter is in any stage except 0 or 1, the counter is set to 1. Transistor Q5 applies the restored reset pulse to Gate C, transistor Q4, and to Gate D, transistor Q6. If the 1 stage of the counter is on, or when the counter has been set to 1, Gate D is enabled. A down pulse applied to the gate is passed to the Range and Polarity Assembly. In manual range mode, the reset pulse is returned directly to the Set 0 input of the 10K decade. In Auto range mode, the output of Gate D is used in the Range and Polarity Assembly to set the DVM to the 10 volt range. A following reset pulse, passed through Gate D, is returned to the Set 0 input. The Set 0 input from the Range and Polarity Assembly triggers transistor Q10, which triggers SCS Q13, setting the counter to 0. Gate D is disabled, and Gate C (Q4) is enabled. Further reset pulses are passed through Gate C to the Range and Polarity Assembly polarity circuit.

RANGE AND POLARITY ASSEMBLY (Schematic 10)

The Range and Polarity Assembly contains up range, polarity, and down range gating circuits.

UP RANGE CIRCUIT

Transistors Q2 and Q3 form a bistable multivibrator which is triggered by a positive up range pulse input, and reset by unijunction transistor Q1. The circuit operates as a one-shot with a time period which changes to meet requirements of different operating modes of the DVM. In the quiescent state Q2 is conducting and Q3 is cut off. Up range pulse inputs can occur only when all decades are in the 9X state and up pulses are still received in the 10K decade logic. An up range pulse triggers Q3 into conduction. Circuit common from the collector of Q3 cuts Q2 off and holds it off. The bistable remains in this state until reset by Q1. Diode CR4 is forward biased, disabling the down range circuits while Q3 is conducting. The negative-going signal from Q3 immediately steps the range counter to advance the instrument to the next higher range. Collector current of Q3 also energizes coil L1, closing S1 to light the RANGE indicator in the front panel display.

When Q2 is cut off, capacitors C1 and C2 commence to charge toward collector supply potential through resistor R3. When the capacitor charge reaches the peak voltage of unijunction transistor Q1, the transistor conducts, coupling a positive signal to the base of Q2. The bistable is reset by the positive input to Q2. The time delay allows the attenuator filter to discharge and assume the correct potential. A second up range pulse is effective only after the circuit has returned to the quiescent state. If the additional filter circuit of the attenuator is used, through the FILTER control on the front panel, the FIL IN terminal is at circuit common. Capacitor C3 is then in parallel with C1 and C2. The increased RC time delay allows the additional filter to discharge to the proper potential when range is changed.

When the DVM RANGE switch is in a manually selected range, or in the 1000V range in AUTO range mode, the range counter cannot step to a higher range. The RANGE indicator in the display flashes to indicate an over range condition. Transistor Q4 controls the on-off flashing time of the indicator with a time delay circuit, to allow sufficient on time for flashing of the indicator to be discernible: when an up range input triggers Q3, transistor Q4 saturates, disabling the up range input circuit for a period controlled by resistor R12 and capacitor C4.

RANGE COUNTER

The range counter is a three-stage ring counter. Each stage controls one of the three voltage ranges

of the DVM. Transistor Q7 is the 10V stage; transistor Q8 is the 100V stage; and transistor Q9 is the 1000V stage. Due to the diodes in the bias circuits, only one stage can conduct at a time. The output of each stage energizes an associated range control relay in the attenuator and decimal point control circuits in the function assembly. Outputs are designated A1, A2, and A3. In manually selected range modes, the RANGE switch forces the range counter stage for the selected range into conduction through inputs M1, M2, or M3. In AUTO range mode, a negative signal from Q3 steps the counter to the next higher stage, until the 1000V stage is conducting. A down pulse input immediately resets the counter to the 10V stage.

When power is first applied to the DVM in AUTO range mode, the range counter is forced to the 10V stage by circuit common applied through the 10K 0 input. The input establishes an initial condition but does not interfere with normal operation.

DOWN RANGE CIRCUIT

The down range signal is a positive pulse from the 10K decade which only occurs when the 10K decade is in 0 or 1 stage, all other decades are in even, 0 stage, and the logic receives down pulses. Transistors Q5 and Q6 form a down range AND gate. When the DVM is not in the 10V range, Q5 is inhibited through the emitter circuit. A down range pulse input is rejected by the down range gate, but is applied to the range counter. The range counter immediately steps to the 10V range. A second down range pulse is accepted by the down range gate, which is enabled in the 10V range. The down range gate resets the 10K decade to 0 through the collector of Q6.

When the DVM is operated in a manually selected range, the down range circuits are disabled.

POLARITY CIRCUIT

The polarity circuits consist of a bistable multivibrator, transistors Q10 and Q11, which is controlled by a bistable multivibrator operating as a time delay one-shot, similar to the one-shot circuit in the up range circuits. In quiescent state, transistor Q12 is cut off, and Q13 is conducting. A polarity input pulse from the 10K decade occurs only when the 10K decade is in 0 stage and a reset pulse is received in the logic. Q13 is cut off by the negative-going trailing edge of the input pulse. As the collector of Q13 becomes positive, it triggers Q12 into conduction. The negative pulse from Q12 triggers the bistable Q10 and Q11 to change state. The polarity signals to the amplifier and polarity indicators in the display are immediately reversed.

When Q13 is cut off, capacitor C commences to charge toward collector supply potential through resistor R52. When the capacitor charge reaches the peak voltage of unijunction transistor Q14, the transistor conducts, applying a positive signal to the base of Q13. Q13 is triggered into conduction, and Q12 is cut off. The polarity circuit cannot respond to additional polarity reset pulses until Q14 has triggered Q13 into conduction. The charge time of the RC network is sufficient to provide proper on-off periods for the display polarity indicators when a series of polarity reset pulses are received.

The polarity circuit output to the negative polarity indicator also energizes the printact polarity relay in the reference assembly. The polarity circuit output to the positive polarity indicator energizes the printact relay in the external reference (ratio) input.

REFERENCE (Schematic 11)

The AC input at terminals 1 and 3 is rectified by diodes CR1 and CR2, and filtered by capacitors C1 and C2. The input to the pre-regulator Module A is 45V DC ±10%. Module B contains the final reference element. The reference output voltages are listed in Note 2 of the schematic. Module A and Module B are a matched pair, with the same serial number on each module. The output of the final reference element, Module B, is connected to a polarity selecting relay, K1. The normally closed contacts of K1 are connected for positive reference output. For negative polarity

K1 is energized by the Range and Polarity Assembly. Potentiometer R4 provides coarse reference voltage adjustment and potentiometer R5 provides fine reference voltage adjustment. Resistors R2 and R3 are selected at the factory, according to the table in schematic Note 2. The resistors narrow the span of coarse and fine calibration adjustment for greater resolution and easier calibration.

NOTE

If, for any reason, service on the reference assembly appears necessary, return the assembly to the factory for correction. Only the coarse and fine adjustments should be handled during routine maintenance. No other changes or adjustments to the reference should be attempted.

POTENTIOMETER BLOCK DIAGRAM (Schematic 12)

The precision potentiometer consists of 5 potentiometer decades in a Kelvin Varley arrangement. Each potentiometer decade corresponds to a number decade in the DVM readout. The schematic shows each potentiometer decade with switch closures corresponding to a number displayed in the readout. Due to the stringent requirements in the 10K potentiometer, a set of ratio-matched resistors, matched to 0.001%, are used. To assure low contact resistance for each contact closure, two parallel reeds are used. In the lower potentiometer decades the effects of contact resistance become negligible and single contacts are used. The 1K potentiometer consists of eleven 10K, 0.01% resistors, ratio-matched to 0.003%, and shunted by a resistor network consisting of a 24.995K, 0.01% resistor in series with a 20Ω trim potentiometer. The 20Ω potentiometer is identified as TRANSFER. The transfer potentiometer is used to ratio-match the total impedance of the thousands potentiometer decade to the individual resistors of the 10K potentiometer. Since all resistors in the 10K potentiometer are ratio-matched to each other, the ratio-match of the 1K potentiometer to the 10K potentiometer is made with any resistor pair in the 10K potentiometer. The ratio-match is checked at major transfers, for example, a transfer from 0.9999 to 1.0000, by observing the error signal with an oscilloscope. If, after the transfer, the DVM is at a true null, the ratio-match is correct. The remaining portion of the potentiometer is a commonly used Kelvin Varley Bridge. The 10K potentiometer is divided into two boards, mounted to each other in a piggy-back fashion, due to the space required for two reeds in parallel for each contact closure.

CAUTION

The wires protruding from each reed in the coil assemblies serve as an extremely low thermal arrangement. Care must be observed when handling this assembly.

10K, 1K, 100, 10 AND UNITS POTENTIOMETER

The potentiometer is a modified Kelvin Varley. In the standard Kelvin Varley Potentiometer, each decade is composed of eleven equal resistors with the exception of the least significant decade which has ten. The only difference in the potentiometer decades is resistor values and the TRANSFER resistor and its adjustment. In a Kelvin Varley arrangement, as used in the 9000 Series, two adjacent resistors in each decade (except the units decade) are shunted by the next lower decade. The shunting decade is arranged to have a total resistance equal to the two resistors being shunted, which reduces the paralleled combination to a value equal to one of the resistors in the more significant decade. The 10K potentiometer, composed of eleven 10K resistors in series, always has an effective resistance of 100KΩ at the end terminals. The resistance of the entire potentiometer is constant, regardless of potentiometer position.

TEN THOUSANDS POTENTIOMETER (Schematic 13)

The 10K potentiometer is the most significant potentiometer. The eleven 10KΩ resistors are matched to 0.001%. Paralleled reeds are used for switching to reduce effects of contact resistance. The relay coils are energized through isolation diodes CR911 through CR920 by transistor drives located on the decade boards.

The reed relay contact arms are made from magnetic iron material. Thermocouples of the iron-copper variety are formed when the reeds are connected to the circuits. Maintaining both ends of each individual reed relay at equal temperatures would cancel the effects of the thermocouples but is not practical. Wires of identical composition to the reed relay contact arms are used to connect the relays to the circuits, transferring the thermocouples to the connection points. Locating the connections in close physical proximity on the circuit board effectively holds them at the same temperature and reduces thermal voltage effects.

An electrostatic shield in each coil is connected to the guard to reduce pickup between adjacent circuits.

THOUSANDS POTENTIOMETER (Schematic 14)

The 1K Potentiometer is also composed of eleven 10KΩ ±0.1% resistors in series but in addition has a resistive shunt in parallel with the eleven divider resistors. The shunt significantly lowers the current in the lower four decades of the potentiometer and is used to reduce effects of contact resistance in the reed relay switches. The shunt consists of R801 and TRANSFER potentiometer R802. R802 provides exact matching of the 1K potentiometer resistance, including the shunt, to equal two of the 10KΩ resistors of the 10K pot. The transfer adjustment setting effects all significant transfers, i.e., 0.9999 to 1.0000; 1.9999 to 2.000 etc.

HUNDREDS POTENTIOMETER
TENS POTENTIOMETER (Schematic 15 and 16)

The potentiometer assemblies are identical except for the resistor values. The 100 potentiometer uses 2KΩ, ±0.025% tolerance resistors and the 10 potentiometer uses 400Ω, ±0.1% resistors.

UNITS POTENTIOMETER (Schematic 17)

The units potentiometer, which has only ten resistors, provides the potentiometer arm output (pot arm) shown as connection B. Each resistor is 82.5Ω ±1.0%.

FUNCTION (Schematic 18)

The function assembly is composed of a number of relays and a diode matrix. On the left side of the schematic three reed relays are shown. Each coil contains two reeds for decimal point control. The coils L1, L2 and L3 are controlled through diodes CR1, CR4 and CR6 from the range and polarity board. The reed switches in the coils are connected as two sets. The first set, S1A, S2A and S3A, are connected to a ratio common line. The second set, S1B, S2B and S3B, are connected to a DC common line. When the voltmeter is operated in the DC mode, circuit common is supplied to the reed switches through diode CR14. The reed relays present a normal decimal point display, indicating a reading in DC volts. When the voltmeter is operated as a ratiometer, circuit common is supplied to the other set of reeds through diode CR12. The decimal point is shifted one place to the left so that the indicated readout is a ratio. D5, D4, D3 and D2 are the connections to the decimal points on the front panel. 1KV, 100V and 10V are the connections for the decimal point drive from the range and polarity board.

Reed relay L4 and S4, identified as POL, supplies +230V to the anode of the polarity indicator. To display polarity in the readout, coil L4 is energized

through diodes CR11, CR13 or CR17. Diode CR11 is returned to an input pin identified as POL (polarity drive). The pin is connected to the plug-in unit. The plug-in unit commands polarity display through this input. +230V comes from the power supply. "Polarity Anode" returns the +230V to the polarity readout indicator if polarity display is desired. "Polarity Drive" is the command line from the plug-in unit which forces polarity display. The range relay, composed of L5 and S5, supplies circuit common to the wiper of the RANGE switch. Coil L5 is only energized when the voltmeter is operated in the basic DC function or DC RATIO function, providing a positive interlock between basic voltmeter operation and plug-in operation. When a plug-in unit is used, the RANGE switch is disabled. The plug-in unit forces the digital voltmeter into whatever range is necessary, regardless of the position of the front panel RANGE switch. Relay K7401, identified as EXT REF POL, is a polarity selector switch for external reference inputs. The relay is a form C relay. In the normally closed (not energized) state, the arm of the relay is connected to the positive external reference input. For negative external reference, K7401 is energized through diode CR38 from the polarity driver on the range and polarity board. The arm of the external reference selector is connected to one contact of the REF SEL relay K7402, also a form C relay. The arm of K7402 is connected through POT HI terminal to the precision potentiometer. In the normally closed (not energized) position of the reference selector, the POT HI terminal is connected to the internal reference high input REF HI. When the voltmeter is operated as a ratiometer, K7402 is energized through diodes CR26, CR29, CR31, CR32 or CR33, connecting the POT HI terminal to the external reference. In some systems applications, it may be preferred to program the external reference input and signal polarity. In this case, the external reference relay K7401 may be omitted and a jumper installed as shown in the schematic with Note 2. The input pin identified as DC is circuit common from the front panel FUNCTION switch when DC function is selected. The circuit common energizes the various relays through diodes CR14, CR13 and CR15. Diode CR18 energizes the input selector relay K12 on the input selector board. Range Wiper is circuit common return for the wiper of the RANGE switch, which is disabled when the instrument is operated with a plug-in unit. AC is circuit common from the FUNCTION switch when the voltmeter is operated in AC function. It provides circuit common to the plug-in indicator on the front panel through diode CR19. KΩ is circuit common when the front panel FUNCTION switch is in the KΩ position. K12 is a drive connection for the input selector relay K12. AUX is circuit common, when AUX is selected on the front panel FUNCTION switch. Plug-in Ind is circuit common returned to the function indicator in the plug-in unit when a plug-in function is selected, to light the plug-in indicator. ACR stands for AC ratio. This is circuit common when AC RATIO function is selected on the front panel FUNCTION switch. DCR stands for DC ratio. This input is circuit common when the front panel FUNCTION switch is in DC RATIO position. Diode CR28 and CR34 apply circuit common to the ratio indicator in the front panel function indicator. In any ratio function diodes CR26, CR33, or CR 3 energize K7402, which connects the external reference to the POT HI. +17V is the power supply for the various relays. EXTERNAL SELECTOR is a control line from the range and polarity board. When negative polarity is involved, this line is circuit common. POT HI is connected to the high terminal of the precision potentiometer, in the 10K potentiometer assembly. REF HIGH is connected to the output high of the internal 10V reference.

FUNCTION INDICATOR (Schematic 19)

The function indicator is located on the readout panel next to the polarity indicator. It provides four indications of operating mode or condition. These indications are RANGE, DC, RATIO and PLUG-IN. The range indicator lights momentarily when the voltmeter makes a decision to range up into the next higher range. The range indicator light flashes when the voltmeter tries to range into the next higher range, but the up range is inhibited. For example, when the voltmeter is operated on the manual 10V

range and an input which exceeds 10V is connected to the DVM signal input, the voltmeter displays 9.9999, the decimal point remains in its fixed position, and the range indicator flashes. The DC indicator lights when the voltmeter is operated in the DC mode. The RATIO indicator lights when the ratio function is selected. In the DC-RATIO function, both indicators, DC and RATIO, light. The PLUG-IN indicator lights when a plug-in function is selected on the DVM FUNCTION selector. For example, with a Model 6700B AC Converter plugged into the DVM and the DVM FUNCTION switch in the AC function, the PLUG-IN indicator lights. The indicators are lit by four neon lamps DS3601 through DS3604. DS3601 is driven through a reed switch on the range and polarity board. The switch is closed when the up range one-shot fires. DS3602 (ratio indicator) is driven from the diode matrix on the function board. At the junction of DS3602 and R3601 a second terminal is connected. This terminal, identified as $\overline{R}$, is not used. Neon DS3603 is operated through diode CR3601 or CR3602. Both diodes are returned to the FUNCTION switch. CR3601 is at circuit common when the FUNCTION switch is in the DC RATIO position. CR3602 is at circuit common when the FUNCTION switch is at DC. The PLUG-IN indicator is driven through diode CR3603, connected into the diode matrix on the function board.

RANGE DETECTOR (Schematic 20)

The range detector assembly contains down range and up range decision circuits which provide down range and up range commands to plug-in accessories through isolated contact closures. The up range detector also provides overrange signals to the print output circuits.

DOWN RANGE DETECTOR

The down range detector provides an isolated contact closure, S1, through relay K1, as a down range command to auto ranging plug-in accessories used with Series 9000B instruments.

The requirements for down range decisions are different for various plug-in units, and for different functions of multi-function units. Recognizing the 10K decade in the Even 0 stage as the only requirement for a down range decision causes unstable ranging points and is therefore insufficient. A down range decision by the down range detector occurs only when the 10K decade is in the Even 0 stage and one of the following conditions exists: the 1K decade is in some number stage other than 9; the 100 decade is in some number stage other than 9; the 10 decade is in some number stage other than 9 and the DVM is not in AC, AC RATIO, AUX, or AUX RATIO.

Transistors Q1, Q2 and Q3 form an OR gate which is connected to the base of Q6 in parallel with transistor Q4. Transistors Q4 and Q5 are a differential pair in which Q4 is normally conducting and Q5 is normally off. Transistor Q6 is forward biased by Q4 or Q1, Q2 and Q3 in series. Forward bias on Q6 holds transistor Q7 back-biased. Switch S1 of reed relay K1 is open. The down range detector reaches a down range decision when

1. circuit common is applied to the base of Q5 by the 10K decade in the Even 0 stage, caus- Q5 to conduct and hold Q4 cut off; and
2. one or more of OR gate transistors Q1, Q2, and Q3 are cut off, allowing the base bias potential of Q6 to drop to circuit common.

When the 1K decade is in some number stage other than 9, diode CR5 is back-biased by the display indicator anode voltage. The base of OR gate transistor Q1 becomes positive, holding the transistor cut off. There is no current flow through resistor R8 and the bias on the base of transistor Q6 drops to circuit common.

When the 100 decade is in some number stage other than 9, diode CR6 is back-biased and transistor Q2 is cut off. There is no current flow through resistor R8 and the bias on the base of transistor Q6 drops to circuit common.

When the DVM FUNCTION switch is in MV, MV RATIO, KΩ, or KΩ RATIO position, and the 10 decade is in some number other than 9, diodes CR1, CR2, CR3, CR4 and CR16 are back-biased, and transistor Q3 is cut off. There is no current flow through resistor R8 and the bias on the base of transistor Q6 drops to circuit common. When the DVM FUNCTION switch is in AC, AC RATIO, AUX, or AUX RATIO position, the respective input diode is forward biased and the condition of the 10 decade does not affect the down range detector circuit.

When transistor Q6 is cut off by the 10K 0 input and one or more transistors of the OR gate being cut off, capacitor C1 starts to charge toward collector supply potential through resistor R15. When the charge on the capacitor reaches the zener voltage of diode CR8 (approximately 6.8 volts), which requires a period of two or three seconds, transistor Q7 is triggered into conduction. Relay K1 is energized, closing switch S1. The time delay prevents false down range signals while the DVM is counting. When Q6 is again forward biased, capacitor C1 discharges through the transistor.

UP RANGE DETECTOR

The up range detector provides an isolated contact closure, S2, through relay K2 as an up range command to plug-in accessories used with series 9000B instruments. The up range detector circuit consists of transistors Q8 and Q10, connected as a one-shot, and clamp transistor Q9. Transistor Q10 is normally saturated and Q8 is normally cut off. Transistor Q9 is also normally off.

When the 10K decade passes an up range signal to the range and polarity assembly the signal is also applied to the up range terminal of the range detector assembly. The positive pulse triggers Q8 into conduction. As Q8 conducts, the negative signal from the collector is coupled through diode CR12 and capacitor C3 to back bias diode CR15. Transistor Q10 is forced to cut off. Diode CR12 cannot pass the signal until collector potential of Q8 has fallen below the zener voltage of zener CR14 (approximately 15 volts). The zener diode desensitizes the one-shot against noise transients. Relay K2 in the collector circuit of Q8 is energized when Q8 is on, closing S2. At the same time an overrange signal is applied to the print output circuits. Transistor Q10 stays in the off condition until capacitor C3 has discharged. When Q10 again conducts, Q8 is cut off. A positive signal from the collector of Q8 is applied to the base of clamp transistor Q9, causing the transistor to saturate, and clamping the base of Q8 at circuit common. Q9 remains saturated until capacitor C2 is charged. While Q9 is saturated, the input circuit is disabled. Continuous up range signals at the input force the up range detector to respond in a periodic on and off sequence. The on period is approximately 50 milliseconds, and the off period is the charge time of C2.

POWER SUPPLY (Schematic 21)

The power transformer is wound with a split primary winding, connected through a slide switch (S8) so that the instrument may be operated from either 230 or 115 volts AC. From the primary winding, leads 2 and 4 provide 115V for the plug-in units. The power transformer, 230/115 volt selector switch S8 and the fuse are mounted on the rear panel. The POWER switch S1 is mounted on the front panel.

Transformer winding 11-12 provides -18V DC through rectifier bridge CR5 - CR8 and filter C2A, R1, C2B. The -18V output is connected to the power supply assembly to provide a convenient test point.

Transformer winding 7 and 8 is connected to a +150V rectifier, consisting of diodes CR9 through CR12, mounted on a rectifier board. The rectified output is connected to section C of triple section electrolytic capacitor C3 on the master board, and to TP10 on the power supply assembly. R4 is a bleeder resistor for discharging the capacitor after power has been turned off.

Transformer winding 5 and 6 is connected to diodes CR13 through CR16 on the rectifier board.

The diodes provide a +240V DC signal which is filtered by capacitor 3A (on the master board), and R1701, giving a filtered +230V DC to the third section of C3B (on the master board). Resistors R2 and R3 are bleeder resistors. The +230V DC can be monitored at TP9 on the power supply assembly.

Transformer winding 1, 2, and 3, with shield 4, is connected to the precision reference assembly.

Transformer winding 9-10 supplies the +22V DC rectifier bridge CR1 - CR4. The rectifier output is filtered by electrolytic capacitor C1A and C1B, and applied to the +17V DC regulated supply through TP8 on the power supply assembly. Transistor Q1 is a passing transistor mounted on the frame of the DVM for heat dissipation, which receives the unregulated +22V as collector supply. The emitter is connected to TP7 through parallel resistors R1707 and R1708. From TP7, feedback is taken through zener diode CR1713 to the base of transistor Q1702. The emitter of Q1702 is returned to a regulated +8.2V (zener diode CR1709). All voltages are indicated in the schematic and should be within 10%. Transistor Q1702 acts as an inverting amplifier which holds the base of series regulator Q1701 at 18.2V DC. The collector of Q1701 is returned to the +22V supply through R1705. Capacitors C1705 and C1706 provide filtering. Diodes CR1710 through CR1712 provide short circuit protection. Since there are two emitter base junctions in series, the voltage drop from the emitter of Q1 to the base of Q1701 is approximately 1.2 volts, and the output is 17.5V DC. If the current through the resistor pair (R1707 and R1708) exceeds 1 ampere, a voltage drop develops across the resistors of more than 0.5V. Under this condition (overload), the voltage drop between TP7 and the base of Q1702 exceeds 8.7V. Diodes CR1710 through CR1712 become forward biased and limit the current through the passing transistor to a maximum of 1 amp, which is a safe rating for the transistor. The +17V supply is overload protected for a continuous short circuit. C1709 provides output filtering for the regulated +17V DC.

PRINT CONTROL (Schematic 22)

The print control assembly detects a null or balance condition in the DVM and issues a print command to a recording device, allowing the DVM reading to be recorded. The print control detects a balance condition in either of two modes, Auto Print or Rebalance. The operating modes are selected at the front panel print control switch. The block diagram in figure 5-4 shows the sequence of events that occur when the PRINT CONTROL switch is in the AUTO PRINT position.

A null detector on the print control assembly detects the presence or absence of drive pulses. As long as drive pulses are present, the DVM is not at balance. If there are no drive pulses, either up or down, the DVM is in a balanced condition. The null detector waits until all drive pulses cease. When the DVM reaches balance, the null detector turns off, simultaneously firing an internal Hold one-shot. The Hold one-shot causes the DVM to hold its present reading until the print cycle is completed. As the Hold one-shot is forced to fire, the Print one-shot energizes a relay coil providing an isolated contact closure as a command to a recording device. When the print cycle is complete, the Hold one-shot turns off and allows the DVM to seek a new reading. In the AUTO PRINT sequence, the DVM continuously tracks the input, and each time a balance condition is detected, a print command is issued.

In the REBALANCE mode, figure 5-5, the PRINT CONTROL switch on the front panel is in the HOLD position. The DVM is held inoperative and cannot track the input signal. Single reading and return to HOLD operation is obtained with a push button switch mounted on the front panel directly above the print control switch, identified as REBALANCE. A momentary contact closure on the REBALANCE push-button causes an override of the hold condition and allows the DVM to seek a null. The rebalance command

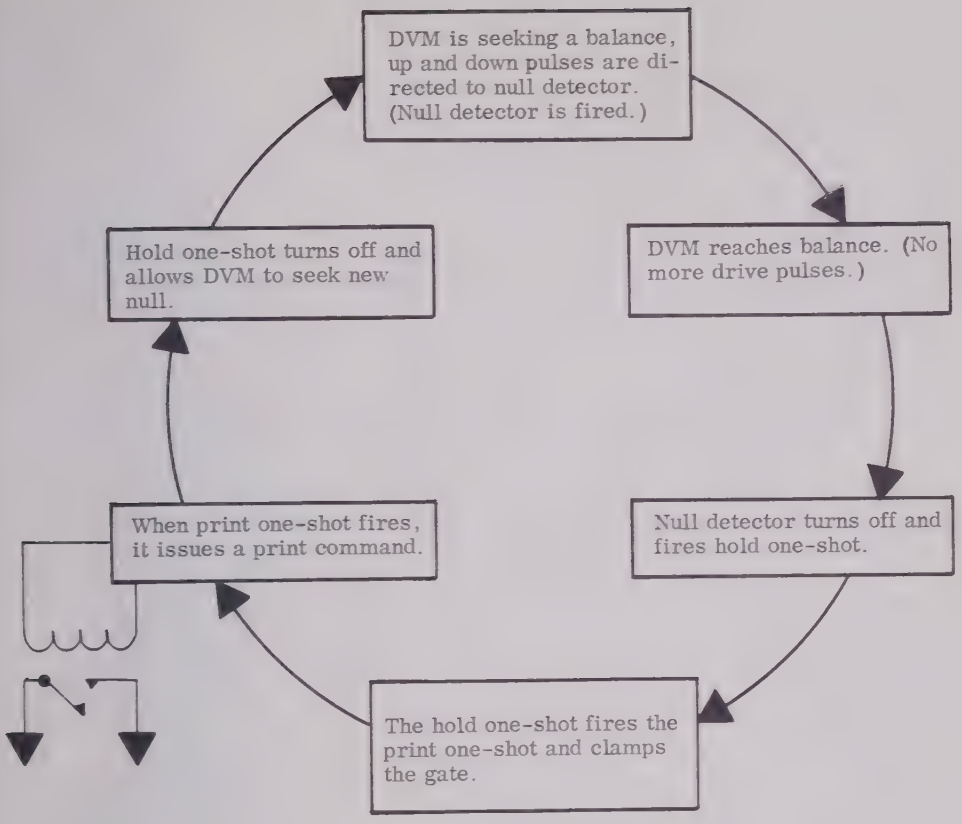

DVM is seeking a balance, up and down pulses are directed to null detector. (Null detector is fired.)
DVM reaches balance. (No more drive pulses.)
Null detector turns off and fires hold one-shot.
The hold one-shot fires the print one-shot and clamps the gate.
When print one-shot fires, it issues a print command.
Hold one-shot turns off and allows DVM to seek new null.

Figure 5-4. Auto Print Sequence.

(contact closure) starts a timing circuit which disables the hold circuit. The timing circuit has an adjustable period of approximately 15 to 25 seconds. Up or down drive pulses are detected by the null detector, causing it to fire. One of two possible conditions may occur; the DVM may or may not find a balance before the time period elapses.

If the DVM finds a balance before the 15 to 25 second timer period has elapsed, the null detector turns off at balance and fires an internal Hold one-shot. As the Hold one-shot fires, the Print one-shot is forced to fire. The Print one-shot energizes the print output relay, providing an isolated contact closure as a print command for a printer or other recording device. As the Print one-shot fires, it turns the timer off. As the timer turns off, a clamp circuit is energized which forces the DVM to return to the HOLD mode. The Hold one-shot then turns off.

If the timer is allowed to turn off by itself due to the failure of the DVM to balance, it forces an Error one-shot to fire at the end of the timing period. This Error one-shot energizes a relay which provides an isolated contact closure, identified as ERROR. This output can be used in a recording device to indicate that "this is not a true reading". As the Error one-shot fires, it causes the hold one-shot to fire and forces the null detector to turn off, preventing an erroneous double print. The Hold one-shot stops the DVM from tracking the input signal and in turn fires the Print one-shot. The Print one-shot causes a contact closure as a print command. The Print one-shot resets the timer and returns the DVM to the HOLD mode.

Block diagram, figure 5-6, shows the sequence of events that will occur if a forced print command is issued. The PRINT CONTROL switch on the front

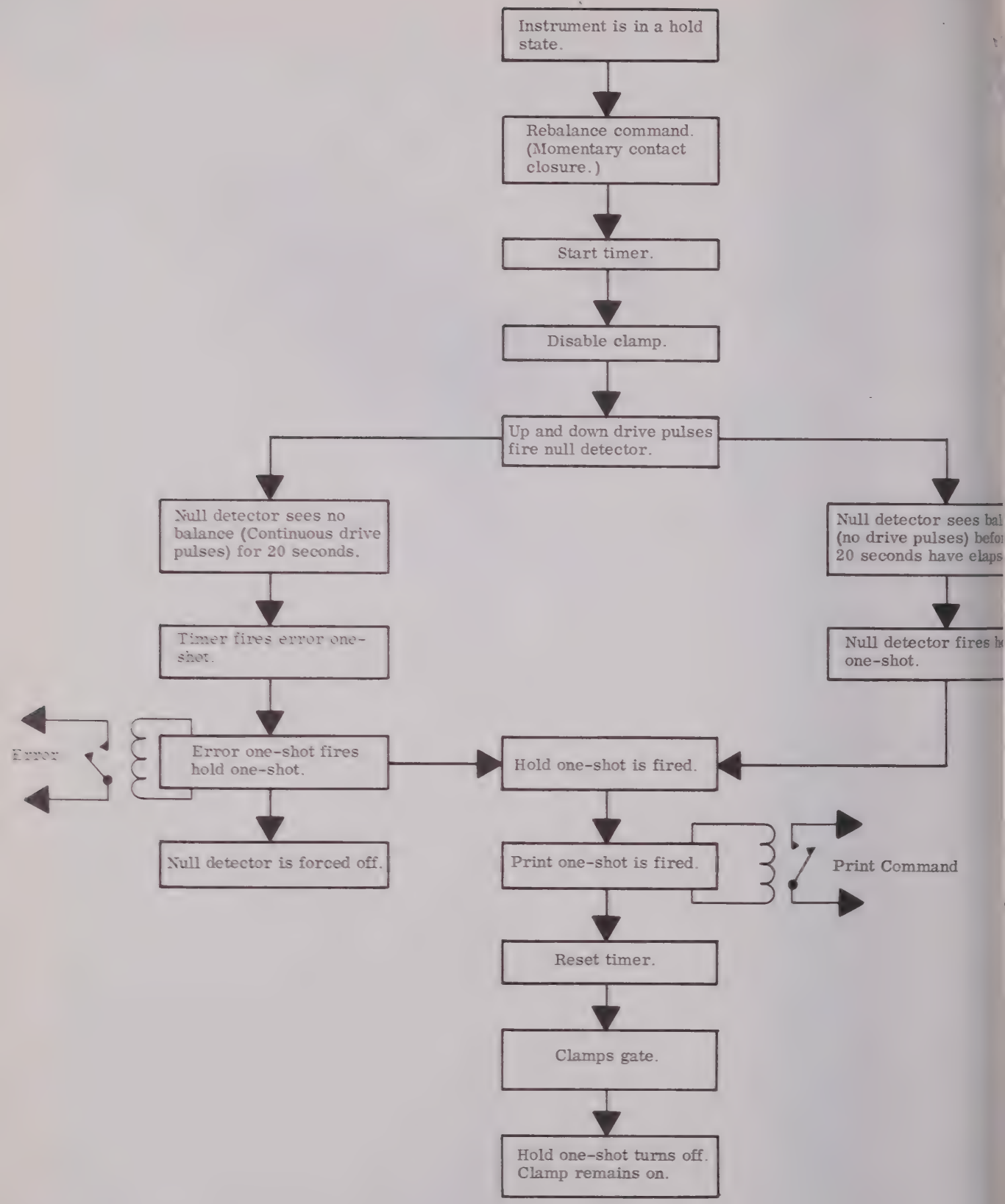

Instrument is in a hold state.
Rebalance command. (Momentary contact closure.)
Start timer.
Disable clamp.
Up and down drive pulses fire null detector.
Null detector sees no balance (Continuous drive pulses) for 20 seconds.
Null detector sees bal
(no drive pulses) befo
20 seconds have elaps
Timer fires error one-shot.
Null detector fires h
one-shot.
Error
Error one-shot fires hold one-shot.
Hold one-shot is fired.
Null detector is forced off.
Print one-shot is fired.
Print Command
Reset timer.
Clamps gate.
Hold one-shot turns off. Clamp remains on.

Figure 5-5. Rebalance Sequence.

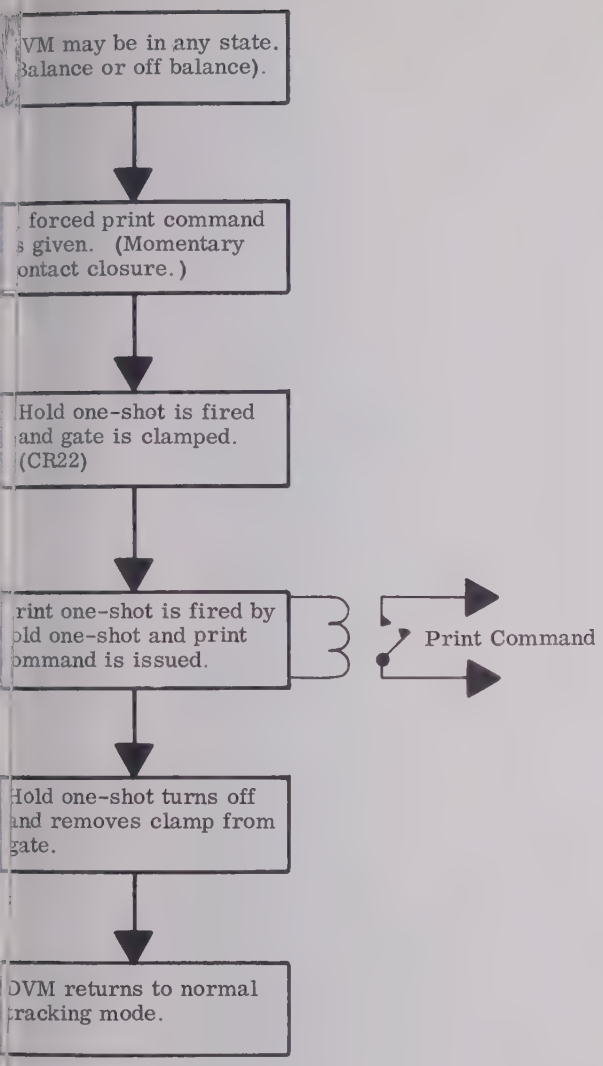


Figure 5-6. Forced Print Sequence.

panel has a position identified as PRINT, which is a spring return position used for a momentary closure. Since it is a spring loaded switch, it is possible to hold this switch manually in the PRINT position. Conditions are shown in the block diagram, figure 5-6. The (forced) print command is for locking the instrument and issuing a print command to a recording device. When the forced print command is given, the internal Hold one-shot is fired, energizing a clamp circuit to lock the DVM. The Hold one-shot in turn fires the Print one-shot to issue a print command. The Hold one-shot turns off when the print cycle is completed so the DVM may continue to track.

Schematic 22 illustrates the print control circuits in more detail. The components of this schematic are grouped in a number of blocks identified as: error detector, null detector, error one-shot, reset one-shot, hold one-shot, clamp and print one-shot. Each block is described individually.

The clamp circuit transistor Q16 collector is connected to the gate of the DVM. Since the gate pulses in the DVM are positive pulses, Q16 when saturated clamps the pulses at circuit common. The up and down drivers cannot detect error signals and therefore cannot fire.

The error detector is a timer circuit, consisting of a binary, Q2 and Q3, an RC timer network, and a clamp transistor, Q1501. In the quiescent state, transistor Q2 is off and transistor Q3 is saturated. With Q2 turned off, forward current is fed through R6 to the base of Q1501. Q1501 is saturated; the collector is near circuit common potential. The timer is started through a REBALANCE command. The momentary contact closure to circuit common forces the binary to change state. Q2 saturates and Q3 turns off. Forward current is no longer applied to the base of Q1501; Q1501 turns off. As Q1501 is turned off, capacitor C1501 starts charging positive through a resistance timer network composed of resistors R1501 and R2. R1501 is variable. When the voltage across C1501 reaches the firing potential of neon DS1501, the neon fires. When DS1501 fires, a positive pulse is generated by means of current sampling in R4. The positive pulse is directed through R33 to the Error one-shot which fires. To reset the timer binary, Q2 and Q3, circuit common is connected through diode CR5 to the collector of Q3 by the Print one-shot. If the timer binary is reset before the neon fires, it causes a quick discharge of capacitor C1501 through transistor Q1501 so no pulse is generated in R4. The Error one-shot fires only if the neon DS1501 fires. The timer binary can be manually reset at any

time. The normal range of the timer adjustment R1501 is 15 to 25 seconds.

NOTE

If a longer or shorter timer period is required, the values of resistors R1501, R2 or capacitor C1501 can be changed.

When the timer turns on (Q8 turned off), a positive pulse is coupled from the collector of Q8 through CR1, R17, and CR6 to the null detector input. The null detector consists of a one-shot (transistors Q4 and Q5) and a recharge transistor (Q6). In the quiescent state transistor Q4 is saturated, transistor Q5 is turned off, and transistor Q6 is turned off. The emitter of Q6 is connected to the -15V supply. Positive pulses coupled to the base of Q6 cause it to saturate and the collector potential moves toward -15V. The positive pulses are coupled to the base of Q6 through C6. Diodes CR4, CR7, CR8, and CR9. Diodes CR8 and CR9 are connected to the up and down drivers of the DVM. Diode CR6 is connected to the output of the error detector. CR7 is connected to the auxiliary print command (APC) input.

CR5 couples a dummy drive pulse to the null detector whenever the timer in the error detector turns on. On the REBALANCE command the timer turns on and the clamp on the gate is removed. If the DVM is already in balance, there are no drive pulses from the driver and the null detector cannot make a decision. Therefore, to start the print out sequence, a dummy drive pulse is coupled to the null detector input, causing the null detector to fire even if there are no up or down pulses.

The Hold one-shot consists of a complementary transistor pair Q12 and Q13. When fired, the Hold one-shot clamps the gate in the DVM and applies a drive pulse to the Print one-shot, causing it to fire. In the normal state transistors Q12 and Q13 are turned off. A positive pulse directed to the base of Q13 causes Q13 to saturate. The positive pulse comes through diode CR14 from the null detector as the null detector turns off. The Hold one-shot can also be fired by grounding the collector of Q13 momentarily by a momentary contact closure of the forced PRINT command. As Q13 saturates, a negative pulse is coupled through C13 and R45 to the base of Q12. Q12 turns on. As Q12 turns on, it supplies forward current through R45 to the base of Q13. Q12 conducts and holds Q13 on until capacitor C13 has discharged. Q12 also supplies forward current to the base of Q16 in the clamp circuit. The discharge time of C13 is adjustable by a trim potentiometer R49 (HOLD) so that the hold or clamp function may be adapted for various systems applications. The adjustment depends on the speed of the printer or recording device employed and the amount of noise which is radiated by certain recording devices. The hold period should be adjusted so that the DVM remains locked for a sufficient time to allow a complete print cycle.

The Print one-shot is a complementary transistor pair. The circuit is similar to the Hold one-shot. It is triggered by a positive pulse through diode CR24 from the Hold one-shot to the base of Q15. As Q15 saturates, it supplies circuit common to a print relay, causing an isolated contact closure as a print command for a printer or other recording device. Q15 also supplies circuit common, identified as a reset timer signal, through diode CR5 to the timer binary in the error detector. When the Print one-shot fires, it forces the timer binary in the error detector to turn off.

The Error one-shot is a complementary transistor pair, consisting of Q6 and Q9. The circuit is similar to the Print one-shot. The error one-shot is fired by a positive pulse applied to the base of Q6 through R23. The positive pulse is generated across R4 when neon D61501 of the error detector fires. Q6 and Q9 saturate. Q9 supplies circuit common to a relay identified as ERROR, an isolated contact closure output signal which identifies a false reading. Q9 also supplies circuit common through diode CR26 to the collector of Q13 in the Hold one-shot, causing the Hold one-shot to fire. In turn the Print one-shot

fires and issues a print command. Q9 also supplies circuit common through CR31 and R57 to the base of Q4. Q4 saturates and causes a rapid discharge of capacitors C6 and C16 through R15 which turns on transistor Q6 in the null detector.

NOTE

When the voltmeter cannot balance, the null detector cannot detect a balance. The error detector forces the Error one-shot to fire. When the Error one-shot fires, the Hold one-shot and Print one-shot fire and issue a print command. Even though the Error one-shot has fired, the null detector is still in the on state because it has received continuous up or down pulses. When the Hold one-shot fires up or down pulses are no longer present. A reset signal from the error detector inhibits the null detector to prevent it from issuing an additional print command.

On command, the Reset one-shot resets all circuits in the print control assembly to an initial state. The reset command is given automatically as the front panel PRINT CONTROL switch is moved to the HOLD position, or is programmed from a remote switch. The Reset one-shot is a complementary transistor pair, consisting of Q10 and Q11. In the quiescent state, the transistors are off. As soon as the HOLD terminal is connected to circuit common, a negative transient is coupled through C11, C10 and R40 to the base of Q10. Q10 saturates and supplies forward current to Q11, which also saturates. Q10 and Q11 conduct until capacitor C10 has discharged. While transistor Q11 is saturated, it supplies circuit common to the Hold one-shot through diode CR19, forcing the Hold one-shot to the off state. Q11 also supplies circuit common through diode CR27 to the Print one-shot, forcing it to the off state. As Q11 saturates, a negative transient is coupled through CR32 and R14 to the base of Q4, which momentarily saturates, resetting the null detector.

Assume the DVM front panel control switch is in the hold position; the DVM is unable to track an input; the input signal is different from the indicated value in the DVM readout; and a rebalance command is given by momentarily closing the REBALANCE push-button. The momentary circuit common starts the timer. As Q2 in the error detector saturates, it applies reverse bias to clamp transistor Q16, disabling the clamp. The DVM can proceed through the logic sequence to find a new balance. As Q3 turns off, a dummy drive pulse is coupled to the null detector, turning it on. Since the input signal is different from the DVM reading as displayed in the readout, up or down pulses are present and the null detector remains on. When the DVM reaches a balance and up or down pulses disappear, the null detector turns off, firing the Hold one-shot through diode CR14. The one-shot clamps the gate so the DVM cannot change the reading and fires the Print one-shot. As the Print one-shot fires, it causes a print command in the form of an isolated contact closure and resets the timer through diode CR5. Resetting the timer causes the clamp transistor Q16 to turn on, as diode CR1501 in the error detector is no longer returned to circuit common, and the rebalance print cycle is complete.

PRINT OUTPUT (Schematic 23)

The print output circuit provides isolated print output in a 10-line decimal code. The electrical equivalent of the circuit is shown as a simplified schematic. The print output assembly consists of three plug-in boards, print output A, print output B, and print output C. Print output A has three additional pins identified as Error, Print, and Overrange. Error and Print are commands from the print control board which provide isolated contact closures for the print output command which occurs after the DVM has found balance, and the error command which occurs after some delay if the DVM did not find balance. Overrange is a command from the range detector board. It provides an isolated contact closure

output if the DVM is in an overrange condition. Print output B has additional pins, identified as (-) minus and (+) plus, which provide contact inclosures to indicate polarity.

MASTER WIRING DIAGRAM DESCRIPTION

This diagram shows the inner connecting wiring between the front panel switches, the readout, the master circuit board, the input logic buffer, the signal input connectors, and the interconnections to and from the plug-in unit.

The diagram is divided into 6 sections. The locations on the diagram are as follows:

1. Front panel switches: lower portion of the diagram.
2. Connections to the readout and function indicator: above the front panel switches.
3. Bottom view of master circuit board: center of diagram.
4. Input selector: left of master circuit board.
5. Signal input connections and connectors (J10A and J10B) to the plug-in unit: left side of diagram.
6. Logic input buffer: top of diagram.

SECTION VI

MAINTENANCE

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GENERAL

Troubleshooting the instrument is extremely simple. Since the majority of components in the instrument are mounted on plug-in boards, troubleshooting is reduced to systematically replacing existing boards with spare boards until the defect is remedied. Down time is reduced to a very few minutes. Faulty boards can be repaired by the user or returned to CIMRON or a CIMRON representative for repair. The user of Series 9000B instruments is urged to become thoroughly familiar with the operation of the instrument before any troubleshooting is attempted.

Pages 6-11 through 6-90 contain information on all plug-in boards. Each board is treated separately; a parts list of all replaceable electronic parts, a picture guide for component location and a schematic of each assembly are provided. The information for

each board is contained on consecutive pages. Pages 6-91 through 6-105 contain schematics showing board interconnections.

The slots into which the various boards fit into the instrument are assigned a number. This number is marked on the rail adjacent to the slot. The number also appears on the plug-in board. In replacing boards it is necessary only to match the board number with the number on the rail. This should preclude any possibility of replacing a board in an improper slot once it has been removed.

Since many of the components used in the instrument are standard electronic parts, the user may obtain them locally if desired. However, it is recommended that precision components and mechanical parts be ordered from the CIMRON representative or direct from the factory.

When replacing components on a printed circuit board, care should be taken to prevent damage to the board from excessive heat. A low wattage soldering iron is recommended for soldering operations on the board or when removing or replacing transistors. Whenever practicable, a heat sink should be used between the soldering point and the transistor body.

DISASSEMBLY FOR MAINTENANCE

Disassembly of the voltmeter for maintenance or for troubleshooting is accomplished as follows:

1. Top Cover. Remove four oval head countersunk phillips head screws securing the top cover to the instrument and remove the cover. A spring-loaded bullet catch is provided to lift one side of the cover away from the instrument to aid in removal.

2. Bottom Cover. Remove four oval head countersunk phillips head screws and remove the bottom cover.

3. Inner Guard Shields. There are two guard shields in the unit, upper and lower The upper guard shield is secured to the instrument by five 4-40 pan head screws. Normal maintenance and adjustment may be accomplished by removing only the upper shield.

4. Plug-in Board Removal. If it is necessary to remove a plug-in board for repair or replacement, always use the wire board puller which is located in a mounted bracket under the guard shield. Insert the board puller from the component side of the board and pull straight out.

CAUTION

Power must be off when removing or replacing board assemblies.

5. Neon Display Tube Removal. Remove the two allen head screws and one of the polarized retainers. The display polarizer may then be snapped out of the front panel. An octal vacuum tube puller may After the display tube is replaced, insert the polarizer first into the still attached retainer and then spring it into position along the opening in the front panel. When nearly into position, slip on the retainer which was removed, position it in place, and replace the screws.

TROUBLESHOOTING

The voltage measurements and wave shapes necessary to indicate proper operation of a plug-in board are listed on the applicable schematic diagrams. These diagrams are placed in the manual in a logical sequence of trouble isolation. Failure to obtain the required voltages or wave shapes usually will indicate which plug-in board is defective. Its replacement should restore the voltmeter to its normal specified

operation. Replacement of the preamplifier, amplifier, logic driver, or reference assemblies will require complete recalibration of the instrument. The procedure for recalibration is outlined in Section IV of this manual.

ADJUSTING PRINT CONTROL POTENTIOMETERS

In AUTO PRINT mode a null detector circuit on the Print Control Assembly is connected to the up and down drive pulse outputs of the DVRM driver circuits. When the DVRM reaches a balance, indicated by the absence of drive pulses, the null detector starts a print cycle. The null detector determines that the DVRM is balanced when no drive pulses are received during a preset period of time, established by the setting of Print Delay potentiometer R23. The null detector starts the print cycle by triggering a Hold one-shot. The Hold one-shot triggers a Print one-shot to generate a print command, and at the same time locks the DVRM to hold the reading until the cycle is completed. The duration of the hold signal is controlled by the setting of Hold potentiometer R49. The required time depends on the speed of the printer or recording device employed. When the print cycle is completed, the Hold one-shot resets and allows the DVRM to seek a new reading. In the AUTO PRINT mode the DVRM continuously tracks the input, and issues a print command each time a balance is established.

PRINT DELAY ADJUSTMENT

An oscilloscope (Tektronix 502 or equivalent) is required for adjusting R23, which provides a delay range of 100 to 500 milliseconds. When making this adjustment mount the Print Control Assembly 90-6015 on an Extender Assembly 80-9501-1.

1. Place voltmeter POWER switch to FILTER OUT, RANGE switch to AUTO, PRINT CONTROL switch to AUTO PRINT, SENSITIVITY control to MAX, and FUNCTION switch to DC.
2. Set oscilloscope sweep to 100ms/cm, Vertical input to DC 5V/cm, and Trigger to -EXTERNAL DC.
3. Connect oscilloscope trigger input to case of Q7 (collector) on the Print Control Assembly.
4. Short DVRM input leads, and allow meter to balance at zero.
5. Hold oscilloscope probe against the case of Q7 (collector).
6. Press REBALANCE control on DVRM.
7. Observe pulse. Adjust R23 for pulse duration greater than period of change of slowest changing voltage to be observed.

HOLD ONE-SHOT ADJUSTMENT

An oscilloscope (Tektronix 502 or equivalent) is required when adjusting R49. Mount the Print Control Assembly 90-6015 on an Extender Assembly 80-9501-1 and use the following procedure to obtain the desired pulse duration:

1. Set the voltmeter POWER switch to FILTER OUT, RANGE switch to AUTO, PRINT CONTROL switch to AUTO PRINT, SENSITIVITY control to MAX, and FUNCTION switch to DC.
2. Set oscilloscope sweep to 100ms/cm, Vertical input to DC 5V/cm, and Trigger to EXTERNAL.
3. Connect oscilloscope trigger input to the case of transistor Q7 (collector) on the Print Control Assembly.
4. Short input leads and allow meter to balance at zero.

5. Hold oscilloscope input probe to the case of Q13 (collector).

6. Press REBALANCE control.

7. Observe pulse display on oscilloscope. Adjust R49 to obtain desired pulse duration.

In HOLD mode the front panel PRINT CONTROL switch is in the HOLD position, keeping the DVRM inoperative and unable to track the input signal. Single reading and return to HOLD operation is obtained by a push button REBALANCE switch on the front panel directly above the PRINT CONTROL switch. Momentary closure of the REBALANCE switch starts a timing circuit which disables the hold circuits and allows the DVRM to seek a null or balance. The timing circuit has an adjustable period of approximately 15 to 25 seconds, controlled by the setting of timer potentiometer R1501. The DVRM may or may not find a balance before the time period elapses. If the DVRM finds a balance the null detector triggers the Hold one-shot, generating a print command and locking the DVRM during the print cycle. The print command resets the timer. When the print cycle is completed, the Hold one-shot resets, returning the DVRM to the HOLD mode. If the DVRM does not find a balance during the time period, the timer triggers an Error one-shot at the end of the time period. The Error one-shot forces the null detector to reset, triggering the Hold one-shot, and generating a print cycle. The Error one-shot also energizes a relay to provide a contact-closure error signal. When the print cycle is completed the Hold one-shot resets, returning the DVRM to the HOLD mode.

TIMER CIRCUIT ADJUSTMENT

R1501 is adjusted in the following manner:

1. Place the voltmeter POWER switch in FILTER OUT, RANGE switch to AUTO, PRINT CONTROL switch to HOLD, SENSITIVITY control at 1, and FUNCTION switch at DC.

2. Hold meter input SIGNAL HI lead in hand, to prevent meter balance.

3. Press REBALANCE control.

4. When meter display stops changing, check time. Elapsed time between pressing REBALANCE control and observing steady readout display is duration of timer control, usually set at approximately 20 seconds. Adjust R1501 to obtain desired time delay.

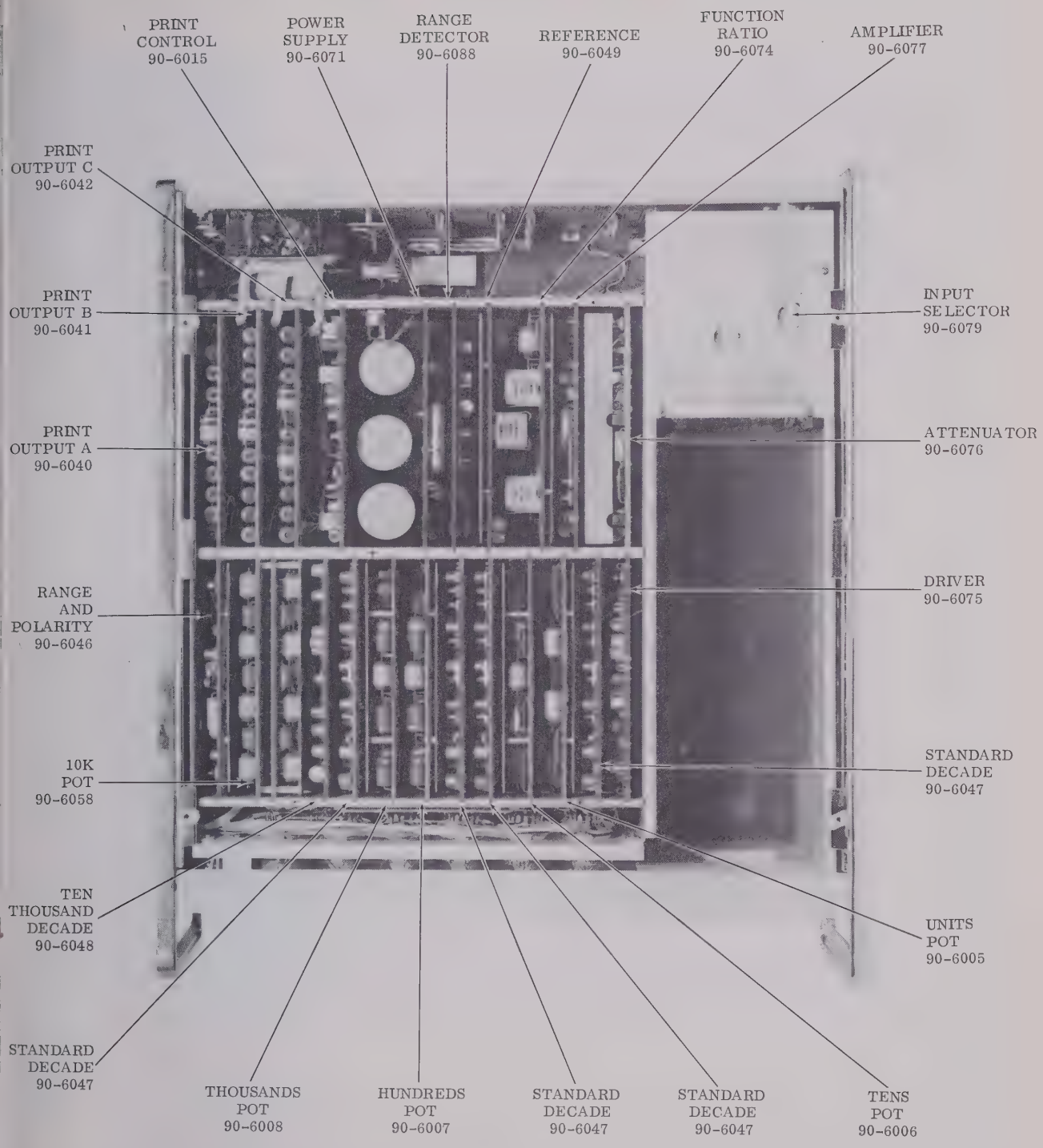


Figure 6-1. Assembly Locations.

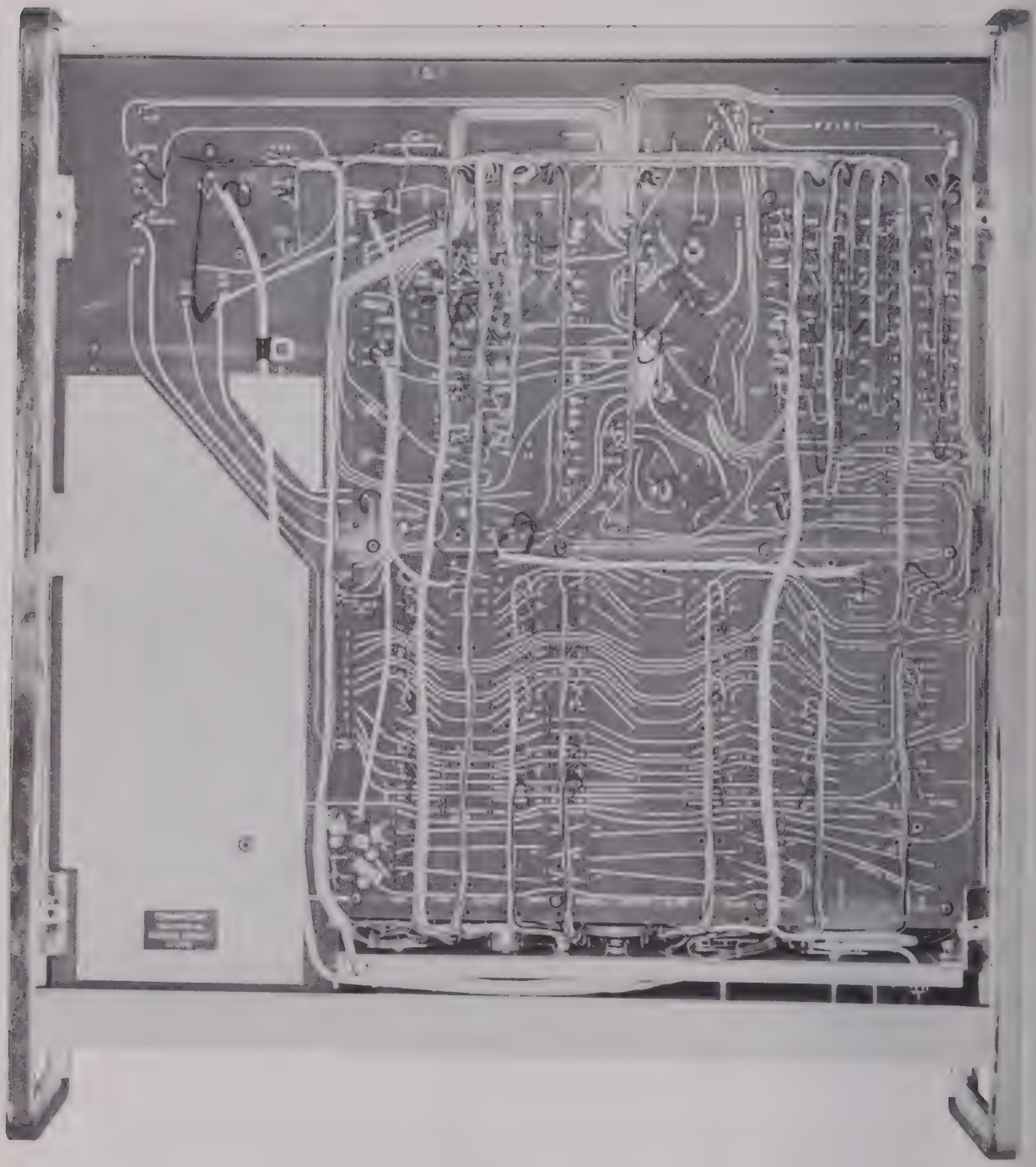
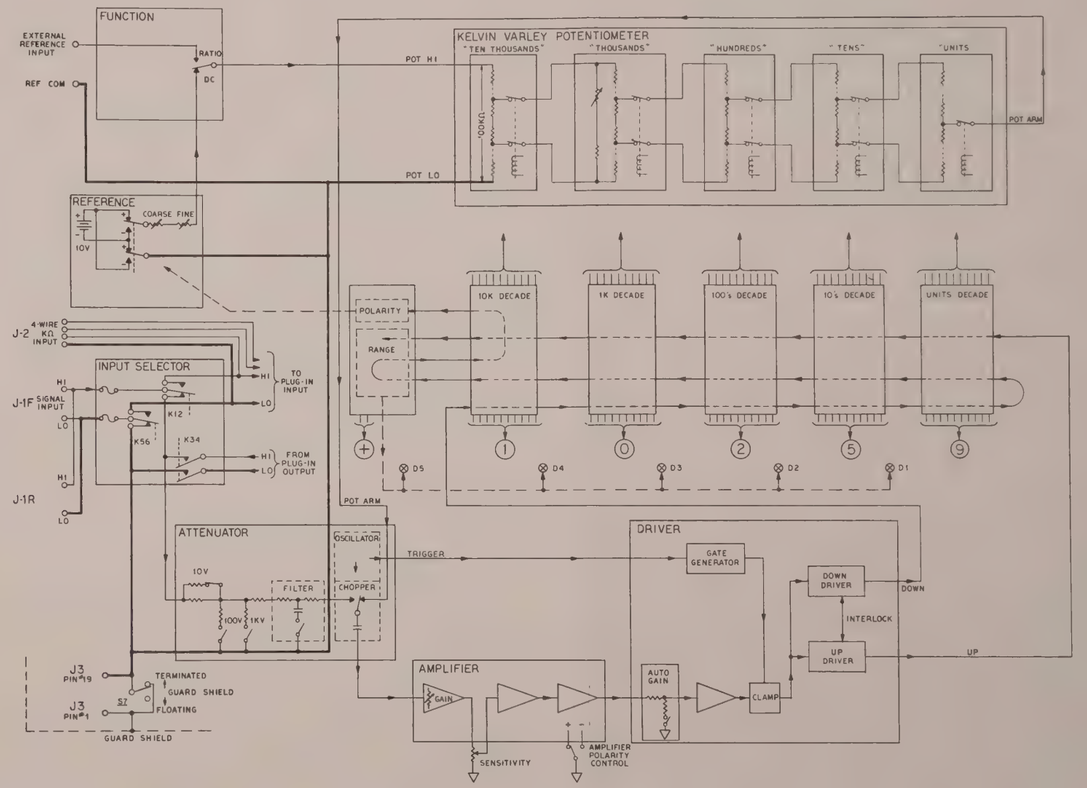
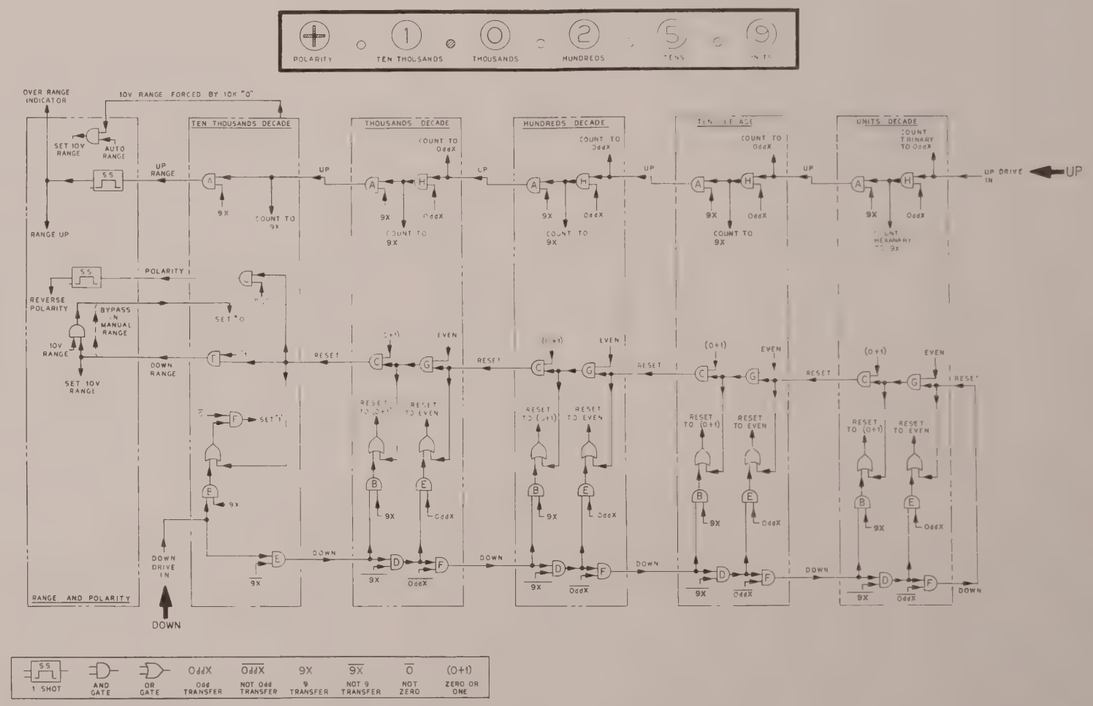


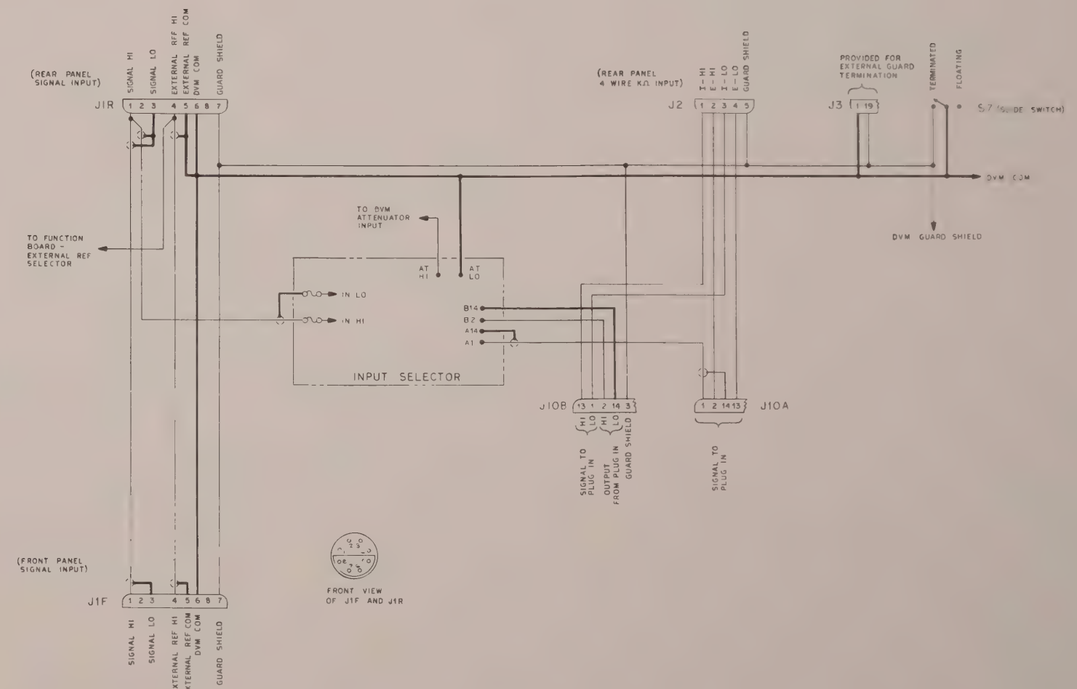
Figure 6-2. Bottom View.



Schematic #1. Signal Circuits Block Diagram.



Schematic 2. Logic Block Diagram.



Schematic #3. Input Signal Connectors Diagram.

INPUT SELECTOR

ASSEMBLY 90-6079

PARTS LIST

ASSEMBLY: Input Selector CIMRON PART NO. 90-6079

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		CIMRON PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
RESISTOR						
R1001	220Ω	COMP	1/2W 5%	01121	EB-2215	7-41035
SEMICONDUCTOR						
CR1001 - CR1003		**CD-61 DIODE		15318		7-95511
CR1004 - CR1006		**CD-62 DIODE		15318		7-95507
SOLENOID						
K1012, K1056		3PDT, 18V		21226	18-BW3-G	7-38214
REED						
S1001, S1002		RELAY		12617	DRR-5	7-38211
COIL						
L1001, L1002		REED SWITCH ACTUATOR		15318		80-0508-1
MISCELLANEOUS		ETCHED BOARD INPUT SELECTOR		15318		90-7079-1
		SHIELD ASSEMBLY INPUT SELECTOR		15318		90-2006-1

NOTE

**CD-61, I_f = 1V greater than 100 ma, I_r = 75V less than 1 ua, SILICON

**CD-62, I_f = 1V greater than 100 ma, I_r = 300V less than 6 ua, SILICON

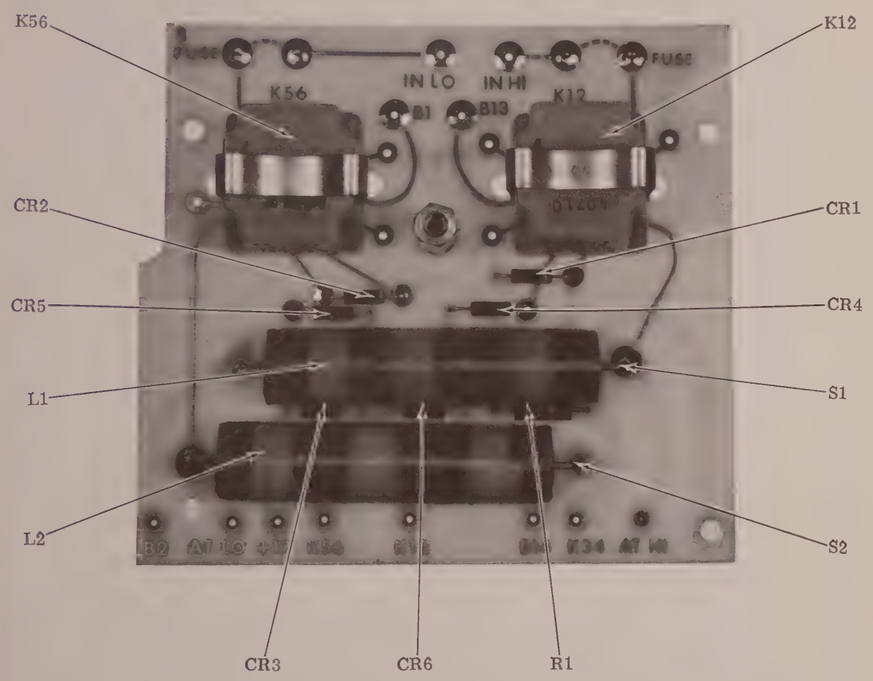
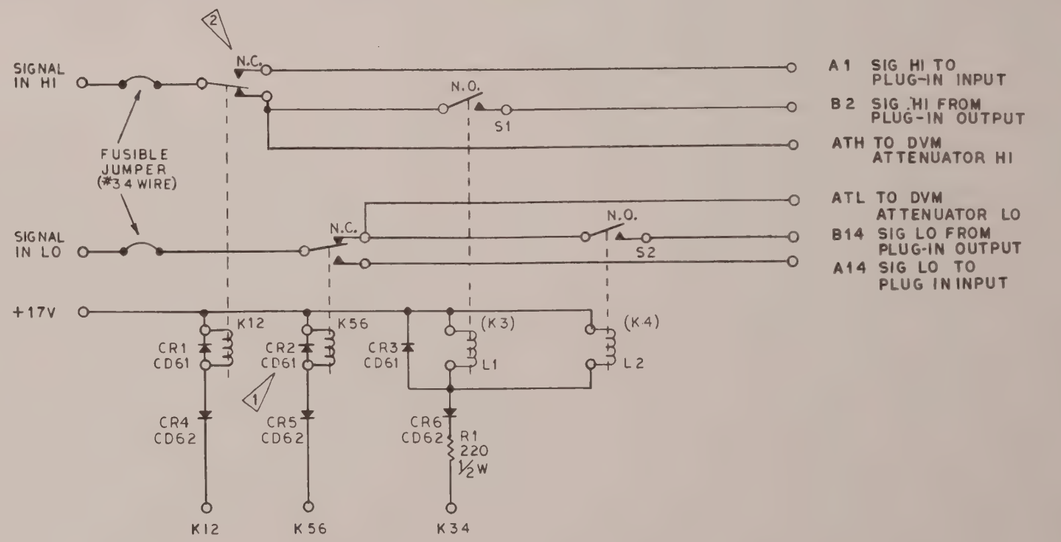


Figure 6-3. Input Selector.



NOTES ◇

1. PARTIAL REFERENCE DESIGNATIONS SHOWN. ALL NUMBERS ARE IN THE SERIES 1001 AND ON. EXAMPLE: CR2 IS CR1002, ETC.
2. RELAYS IN DC FUNCTION POSITION, K12 ENERGIZED.

CAUTION IN ORDER TO ASSURE LOW LEAKAGE AND HIGH INPUT IMPEDANCE USE **CLEAN NYLON GLOVES** WHEN HANDLING THIS BOARD ASSY.

Schematic 4. Input Selector.

ATTENUATOR

ASSEMBLY 90-6076

PARTS LIST

ASSEMBLY: Attenuator CIMRON PART NO. 90-6079

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		CIMRON PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
CAPACITOR						
C7601 - C7602	5.14nf	POLY	200V 1%	12406	PD2A5141F	1-57346
C7603 - C7604	0.1uf	POLY	200V 20%	12406	PD2363	1-57309
C7605	0.015uf	POLY	200V 20%	12406	PD2362	1-57310
C7606	10nf	POLY	200V 1%	12406	PD2A103F	1-57338
C7607	1nf	GLASS	500V 10%	07115	CYFM15C102K	1-57602
C7608 - C7609	560pf	GLASS	500V 10%	07115	CYFM20C561K	1-57600
RESISTOR						
R7601	10MΩ	MET FILM	2W 0.25%	07716	MEC-T9	7-46121
R7602	560KΩ	COMP	2W 5%	01121	HB-5645	7-45076
R7603	100.75KΩ	WW	1/4W 0.05%	07088	OB	7-47200
R7604	105KΩ	MET FILM	1/2W 0.25%	07716	MEC-T9	7-46135
R7605	523KΩ	DEP CAR	1/8W 1%	07716	RN-60B	7-46522
R7607	255KΩ	MET FILM	1/8W 1%	07716	MEA	7-46139
R7608	523KΩ	DEP CAR	1/8W 1%	07716	RN-60B	7-46522
R7609	330KΩ	COMP	1/4W 5%	01121	CB-3345	7-41273
R7610	220KΩ	COMP	1/4W 5%	01121	CB-2245	7-41271
R7611	56KΩ	COMP	1/4W 5%	01121	CB-5635	7-41264
R7612	500Ω	VAR TRIM WW	1/4W	80294	275-1-501	7-54206
R7613	1MΩ	MET FILM	1/2W 0.25%	07716	MEC-T9	7-46120
R7614	10KΩ	VAR TRIM WW	1/4W	80294	275-1-103	7-54103
R7615	2.2MΩ	COMP	1/4W 5%	01121	CB-2255	7-41283
R7616	470Ω	COMP	1/2W 5%	01121	EB-4715	7-41039
SEMICONDUCTOR						
CR7601 - CR7604		**CD-61 DIODE		15318		7-95511
CR7605 - CR7608		**CD-62 DIODE		15318		7-95507
CR7609 - CR7610		FD300 DIODE		72314	FD-300	7-95505
TRANSISTOR						
Q7601		2N3088A		JEDEC	2N3088A	9-04717
REED						
S7601		RELAY		12617	DRR-5	7-38211
S7602 - S7604		RELAY		12617	DRG-1	7-38208

PARTS LIST

ASSEMBLY: Attenuator CIMRON PART NO. 90-6079

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
COIL						
L7601		REED SWITCH ACTUATOR		15318		80-0508-1
L7602 - L7604		REED SWITCH ACTUATOR		15318		70-0501-1
MISCELLANEOUS						
A7601		CHOPPER		15318		1-92004
DS1, DS2		LAMP, GLOW, NE-2H		15318		5-46501
		SOCKET 7 PIN		11769	705-02	8-24102
		MOUNTING BRACKET		15318		70-2005-1
		SHIELD ASSEMBLY, ATTENUATOR		15318		90-2005-3

NOTE

**CD-61, If = 1V greater than 100ma, I_r = 75V less than 1ua, SILICON

**CD-62, I_f = 1V greater than 100ma, I_r = 300V less than 6ua, SILICON

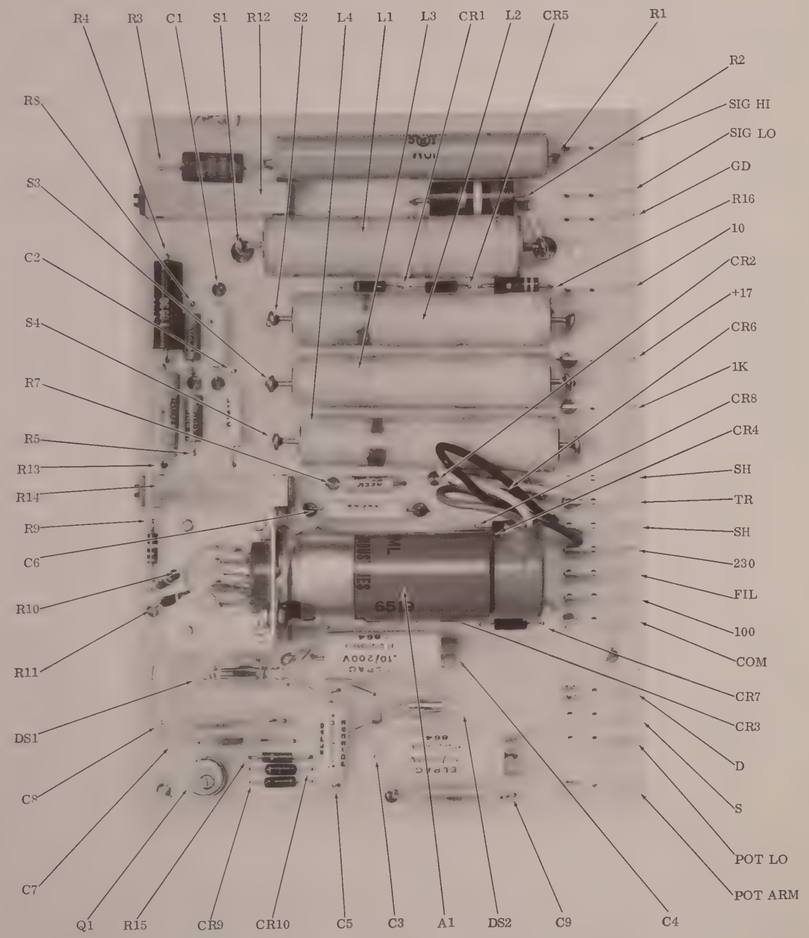
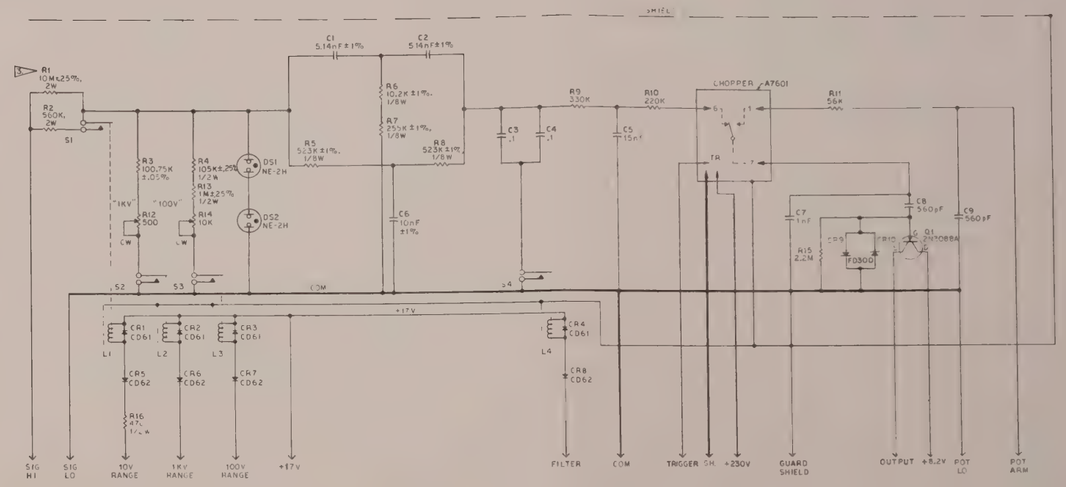


Figure 6-4. Attenuator.



NOTES ◇

1. ALL RESISTORS ±5%, 1/4W UNLESS NOTED OTHERWISE
2. ALL CAPACITORS ARE SHOWN IN μF UNLESS NOTED OTHERWISE.

▷ PARTIAL REFERENCE DESIGNATIONS SHOWN. ALL NUMBERS ARE IN SERIES 7601 AND ON. FOR COMPLETE DESIGNATION ADD 7600 TO DIGITS SHOWN. EXAMPLE: A1 IS R7601.

CAUTION IN ORDER TO ASSURE LOW LEAKAGE AND HIGH INPUT IMPEDANCE USE **CLEAN NYLON GLOVES** WHEN HANDLING THIS BOARD ASSY.

Schematic 5. Attenuator.

AMPLIFIER

ASSEMBLY 90-6077

PARTS LIST

ASSEMBLY: Amplifier CIMRON PART NO. 90-6077

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		CIMRON PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
CAPACITOR						
C203	20uf	ELECT	15V	14655	NLW 20-15	1-57246
C204	2.2uf	TANT	35V 20%	01295	SCM225BP035D4	1-57104
C205	20uf	ELECT	15V	14655	NLW 20-15	1-57246
C206	0.47uf	MET PAP	50V 10%	12406	VX5A474K	1-57318
C207	5nf	DISC	50V	71590	CK-502	1-57512
C208	1nf	DISC	1000V 10%	71590	DD-102	1-57504
C209	100uf	ELECT	15V	14655	NLW 100-15	1-57247
C210	6uf	ELECT	15V	14655	NLW 6-15	1-57245
C212	0.1uf	MET PAP	50V	12406	VX5A154K	1-57321
C214	0.1uf	MET PAP	50V	12406	VX5A154K	1-57321
C215, C216	25uf	ELECT	25V 85°	14655	NLW 25-25	1-57223
C217	0.22uf	MET PAP	50V	12406	VX5A224K	1-57319
RESISTOR						
R204	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R205	332Ω	DEP	1/8W 1%	00656	TYPE CPM	7-46513
R206, R207	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R208	332Ω	DEP	1/8W 1%	00656	TYPE CPM	7-46513
R209	5KΩ	VAR TRIM WW	1/4W	80294	275-1-502	7-54207
R212	1.8KΩ	COMP	1/4W 5%	01121	CB-1825	7-41246
R213	680Ω	COMP	1/4W 5%	01121	CB-6815	7-41241
R214	2.2KΩ	COMP	1/4W 5%	01121	CB-2225	7-41247
R215	33KΩ	COMP	1/4W 5%	01121	CB-3335	7-41261
R216	82KΩ	COMP	1/4W 5%	01121	CB-8235	7-41266
R217	680Ω	COMP	1/4W 5%	01121	CB-6815	7-41241
R218	47KΩ	COMP	1/4W 5%	01121	CB-5735	7-41263
R219	1KΩ	COMP	1/4W 5%	01121	CB-1025	7-41243
R220	47KΩ	COMP	1/4W 5%	01121	CB-5735	7-41263
R221	39KΩ	COMP	1/4W 5%	01121	CB-3935	7-41262
R222	1KΩ	COMP	1/4W 5%	01121	CB-1025	7-41243
R223	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R224	1.5KΩ	COMP	1/4W 5%	01121	CB-1525	7-41245
R225	5.6KΩ	COMP	1/4W 5%	01121	CB-5625	7-41252
R226	12KΩ	COMP	1/4W 5%	01121	CB-1235	7-41256
R227	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R228	180KΩ	COMP	1/4W 5%	01121	CB-1845	7-41270
R229	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R230	1.5KΩ	COMP	1/4W 5%	01121	CB-1525	7-41245
R231, R232	10KΩ	DEP	1/8W 1%	00656	TYPE CPM	7-46501

PARTS LIST

ASSEMBLY: Amplifier CIMRON PART NO. 90-6077

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
RESISTOR (Cont'd)						
R233	1KΩ	COMP	1/4W 5%	01121	CB-1025	7-41243
R235	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R236	255Ω	DEP	1/8W 1%	07716	TYPE RN603	7-46523
R237	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R238	10KΩ	DEP	1/8W 1%	00656	TYPE CPM	7-46501
R239	255Ω	DEP	1/8W 1%	07716	TYPE RN603	7-46523
R240	180KΩ	COMP	1/4W 5%	01121	CB-1845	7-41270
R241	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R243	18KΩ	COMP	1/4W 5%	01121	CB-1835	7-41258
R244, R245	100Ω	COMP	1/4W 5%	01121	CB-1015	7-41231
R246, R247	1KΩ	DEP	1/8W 1%	00656	TYPE CPM	7-46511
R249	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R250	18KΩ	COMP	1/4W 5%	01121	CB-1835	7-41258
SEMICONDUCTOR						
CR204		1N708A Z - DIODE		JEDEC	1N708A	7-95631
CR205, CR206		1N712A Z - DIODE		JEDEC	1N712A	7-95632
CR209, CR210		1N716A Z - DIODE		JEDEC	1N716A	7-95614
TRANSISTOR						
Q203 - Q208		**CT-26		15318		9-04710
Q209		2N404A		JEDEC	2N404A	9-04609
Q210		**CT-31		15318		9-04800
Q211		**CT-20		15318		9-04701
Q212 - Q216		**CT-26		15318		9-04710
MISCELLANEOUS						
TP1		TEST JACK, BROWN		82042	TJ-51-3	5-19003
TP2		TEST JACK, RED		82042	TJ-51-4	5-19004
TP3		TEST JACK, ORANGE		82042	TJ-51-2	5-19002
TP4		TEST JACK, YELLOW		82042	TJ-51-6	5-19006
		ETCHED BOARD, AMPLIFIER		15318		90-7002-1

NOTE

**CT-20 = 2N697

**CT-26 = 2N2222

**CT-31 = 2N1131

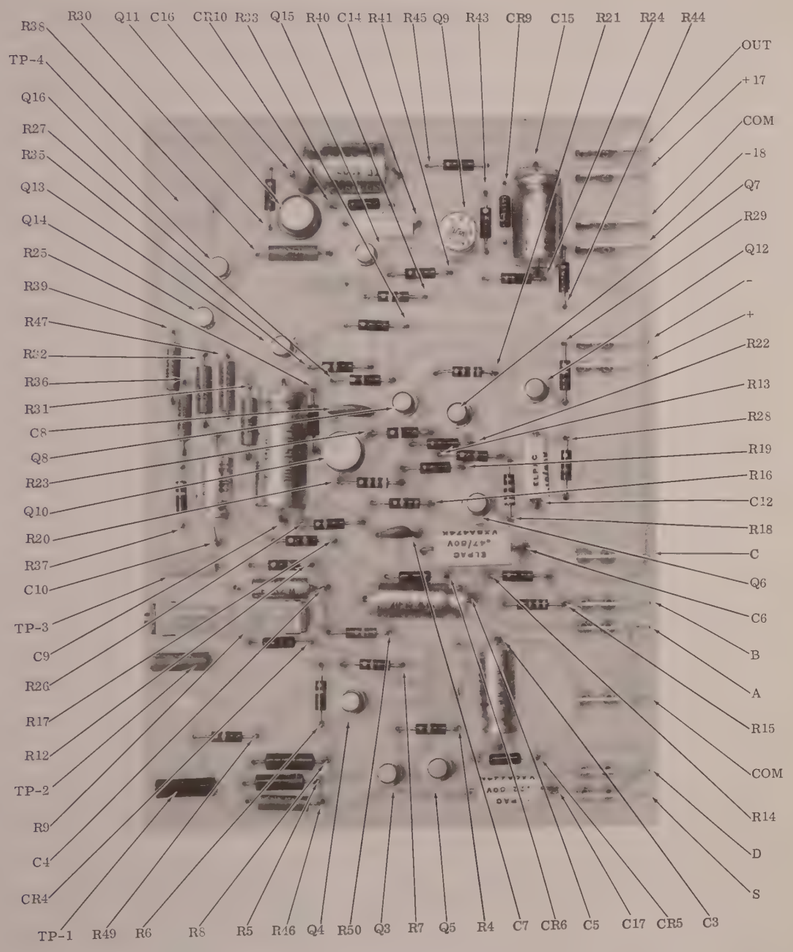
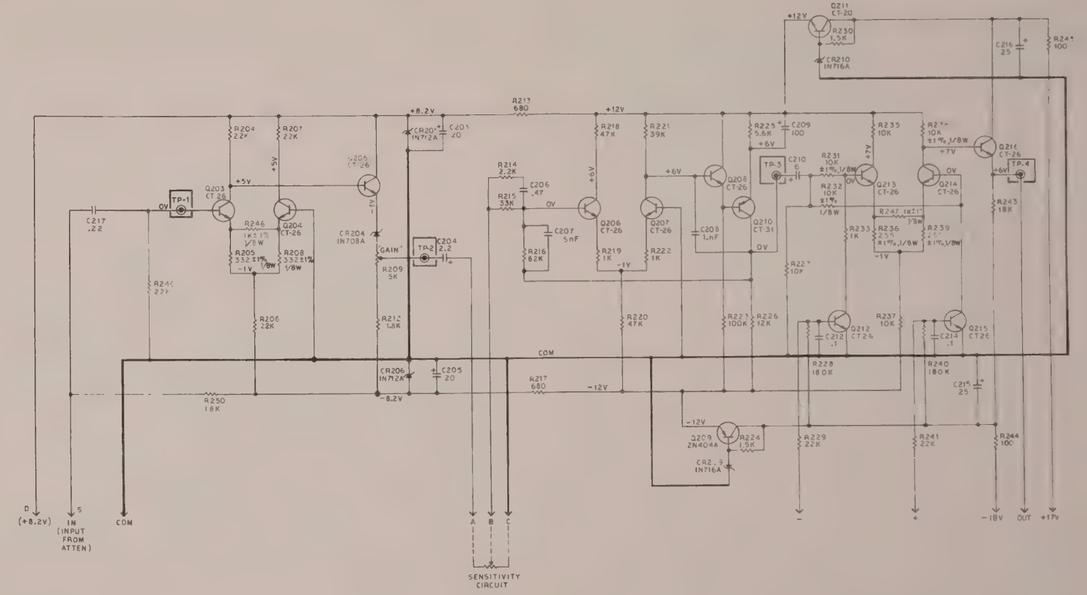


Figure 6-5. Amplifier.

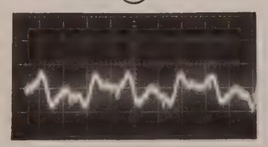


NOTES ◇

1. ALL DIODES ARE CD-61 UNLESS NOTED OTHERWISE.
2. ALL RESISTORS ARE ±5%, 1/4W UNLESS NOTED OTHERWISE.
3. ALL CAPACITORS ARE SHOWN IN μF UNLESS NOTED OTHERWISE

Schematic 6. Amplifier.

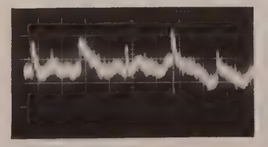
TP ①



SCOPE SETTING

VERTICAL SENSITIVITY 0.1uV/CM
HORIZONTAL SWEEP 5MS/CM

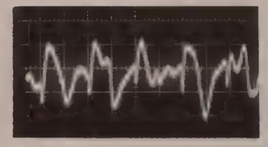
TP ②



SCOPE SETTING

VERTICAL SENSITIVITY 0.5MV/CM
HORIZONTAL SWEEP 5MS/CM

TP ③



SCOPE SETTING

VERTICAL SENSITIVITY 5MV/CM
HORIZONTAL SWEEP 5MS/CM

TP ④

SCOPE SETTING

VERTICAL SENSITIVITY 0.1V/CM
HORIZONTAL SWEEP 5MS/CM

DRIVER

ASSEMBLY 90-6075

PARTS LIST

ASSEMBLY: Driver CIMRON PART NO. 90-6075

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
CAPACITOR						
C7501, C7502	10uf	ELECT	25V	14655	NLW 10-25	1-57250
C7503	25uf	ELECT	25V	14655	NLW 25-25	1-57223
C7504	.47uf	MET PAP	50V 10%	12406	VX5A474K	1-57318
C7505	20uf	ELECT	15V	14655	NLW 20-15	1-57246
C7506	.068uf	MET PAP	50V 10%	12406	VX5A683K	1-57322
C7507	0.0018uf	DISC	1000V 10%	71590	DD-182	1-57503
C7508	.068uf	MET PAP	50V 10%	12406	VX5A683K	1-57322
C7509	2.2uf	TANT	20V 10%	56289	150D225X9020A2	1-57108
C7510	.015uf	MET PAP	50V 10%	12406	VX5A153K	1-57329
C7511	0.001uf	DISC	1000V 10%	71590	DD-102	1-57504
C7512	.047uf	MET PAP	50V 10%	12406	VX5A473K	1-57327
C7513	20uf	ELECT	15V	14655	NLW 20-15	1-57246
C7514	0.0018uf	DISC	1000V 10%	71590	DD-182	1-57503
C7515	.068uf	MET PAP	50V 10%	12406	VX5A683K	1-57322
C7516	.047uf	MET PAP	50V 10%	12406	VX5A473K	1-57327
C7517	.005uf	DISC	50V 20%	71590	CK-502	1-57512
RESISTOR						
R7501	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R7502	2.2KΩ	COMP	1/4W 5%	01121	CB-2225	7-41247
R7503	6.8KΩ	COMP	1/4W 5%	01121	CB-6825	7-41253
R7504	12KΩ	COMP	1/4W 5%	01121	CB-1235	7-41256
R7505	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R7506	33KΩ	COMP	1/4W 5%	01121	CB-3335	7-41261
R7507	12KΩ	COMP	1/4W 5%	01121	CB-1235	7-41256
R7508	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R7509	56KΩ	COMP	1/4W 5%	01121	CB-5635	7-41264
R7510	68KΩ	COMP	1/4W 5%	01121	CB-6835	7-41265
R7511	12KΩ	COMP	1/4W 5%	01121	CB-1235	7-41256
R7512	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R7513	56KΩ	COMP	1/4W 5%	01121	CB-5635	7-41264
R7514	27KΩ	COMP	1/4W 5%	01121	CB-2735	7-41260
R7515	12KΩ	COMP	1/4W 5%	01121	CB-1235	7-41256
R7516	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R7517	56KΩ	COMP	1/4W 5%	01121	CB-5635	7-41264
R7518	27KΩ	COMP	1/4W 5%	01121	CB-2735	7-41260
R7519	12KΩ	COMP	1/4W 5%	01121	CB-1235	7-41256
R7520	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R7521	56KΩ	COMP	1/4W 5%	01121	CB-5635	7-41264

PARTS LIST

ASSEMBLY: Driver CIMRON PART NO. 90-6075

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		CIMRON PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
RESISTOR (Cont'd)						
R7522	33KΩ	COMP	1/4W 5%	01121	CB-3335	7-41261
R7523	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R7524, R7525	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R7526	15KΩ	COMP	1/4W 5%	01121	CB-1535	7-41257
R7527	255Ω	DEP CAR	1/8W 1%	00656	CPM	7-46523
R7528	15KΩ	COMP	1/4W 5%	01121	CB-1535	7-41257
R7529	255Ω	DEP CAR	1/8W 1%	00656	CPM	7-46523
R7530	33KΩ	COMP	1/4W 5%	01121	CB-3335	7-41261
R7531	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R7532	1KΩ	COMP	1/4W 5%	01121	CB-1025	7-41243
R7533	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R7534	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R7535	56KΩ	COMP	1/4W 5%	01121	CB-5635	7-41264
R7536, R7537	22.1KΩ	DEP CAR	1/8W 1%	00656	CPM	7-46506
R7538	5KΩ	VAR TRIM WW	1/4W	80294	275-1-502	7-54207
R7539	3.32KΩ	DEP CAR	1/8W 10%	00656	CPM	7-46504
R7540	47.5KΩ	DEP CAR	1/8W 1%	00656	CPM	7-46502
R7541	1.5KΩ	COMP	1/4W 5%	01121	CB-1525	7-41245
R7542	1KΩ	COMP	1/4W 5%	01121	CB-1025	7-41243
R7543	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R7544	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R7545	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R7546	39KΩ	COMP	1/4W 5%	01121	CB-3935	7-41262
R7547, R7548	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R7549	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R7550	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R7551	1.5KΩ	COMP	1/4W 5%	01121	CB-1525	7-41245
R7552	3.3KΩ	COMP	1/4W 5%	01121	CB-3325	7-41249
R7553	1MΩ	COMP	1/4W 5%	01121	CB-1055	7-41279
R7554	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R7555	15KΩ	COMP	1/4W 5%	01121	CB-1535	7-41257
R7556	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R7557	12KΩ	COMP	1/4W 5%	01121	CB-1235	7-41256
R7558	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R7559	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R7560	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R7561	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R7562	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R7563, R7564	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259

PARTS LIST

ASSEMBLY: Driver CIMRON PART NO. 90-6075

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
RESISTOR (Cont'd)						
R7565	1.5KΩ	COMP	1/4W 5%	01121	CB-1525	7-41245
R7566	1KΩ	COMP	1/4W 5%	01121	CB-1025	7-41243
R7567	47.5KΩ	DEP CAR	1/8W 1%	00656	CPM	7-46502
R7568	6.81KΩ	DEP CAR	1/8W 1%	00656	CPM	7-46515
R7569	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R7570	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R7571	39KΩ	COMP	1/4W 5%	01121	CB-3935	7-41262
R7572	1.2KΩ	COMP	1/4W 5%	01121	CB-1225	7-41244
R7573	3.9KΩ	COMP	1/4W 5%	01121	CB-3925	7-41250
R7574 - R7576	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R7577, R7578	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R7579	56KΩ	COMP	1/4W 5%	01121	CB-5635	7-41264
R7580	12KΩ	COMP	1/4W 5%	01121	CB-1235	7-41256
SEMICONDUCTOR						
CR7501 - CR7511		**CD-62 DIODE		15318		7-95507
CR7512, CR7513		**CD-61 DIODE		15318		7-95511
CR7514		ZENER 1N712A		JEDEC	1N712A	7-95632
CR7515		ZENER 1N716A		JEDEC	1N716A	7-95614
CR7516 - CR7522		**CD-61 DIODE		15318		7-95511
CR7523		ZENER 1N716A		JEDEC	1N716A	7-95614
CR7524		**CD-61 DIODE		15318		7-95511
TRANSISTOR						
Q7501 - Q7505		2N404A		JEDEC	2N404A	9-04609
Q7506 - Q7508		**CT-26		15318		9-04710
Q7509		2N404A		JEDEC	2N404A	9-04609
Q7510		**CT-26		15318		9-04710
Q7511		2N2944		JEDEC	2N2944	9-04615
Q7512 - Q7514		2N1304		JEDEC	2N1304	9-04500
Q7515		2N404A		JEDEC	2N404A	9-04609
Q7516 - Q7518		**CT-26		15318		9-04710
Q7519 - Q7522		2N404A		JEDEC	2N404A	9-04609
MISCELLANEOUS						
		ETCHED BOARD, DRIVER		15318		90-7075-1

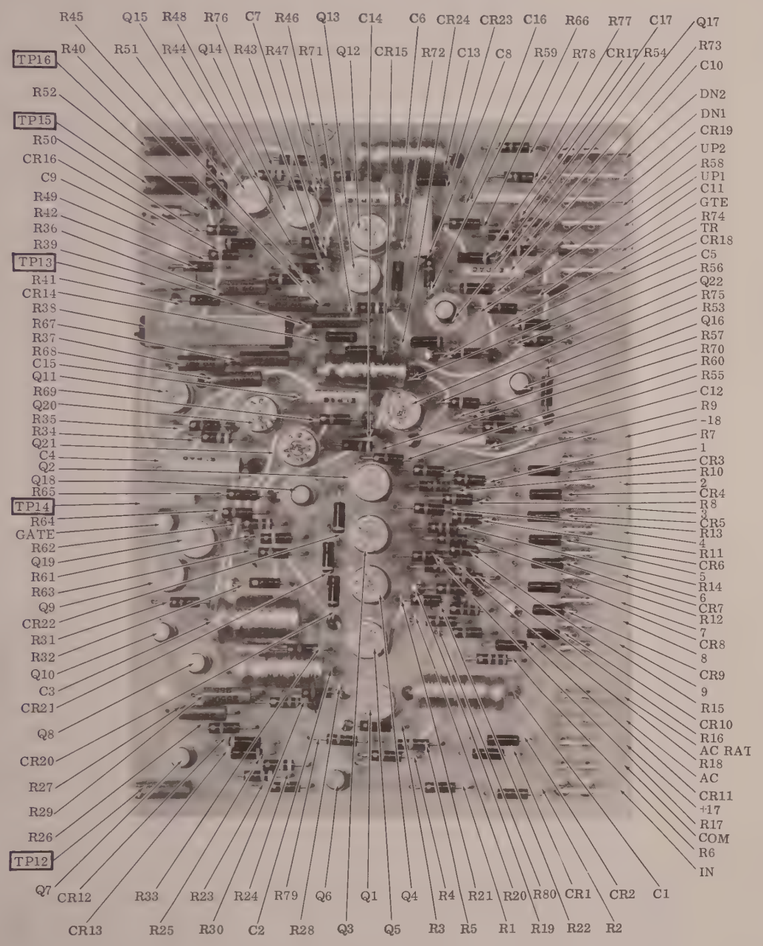
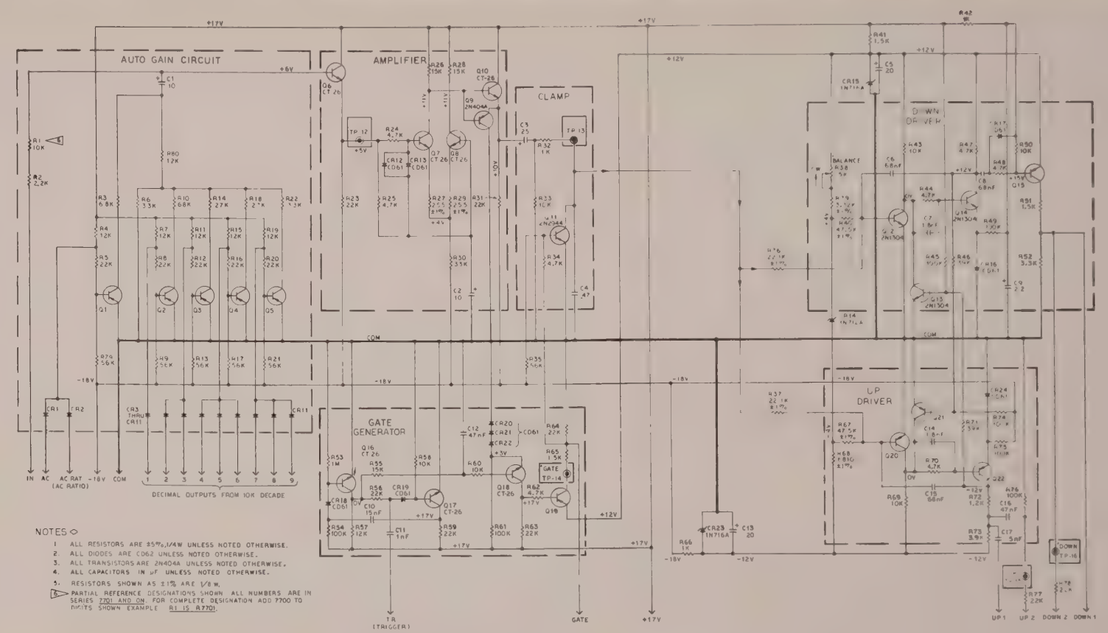
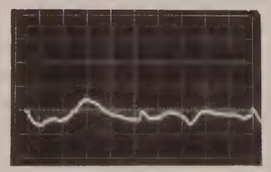


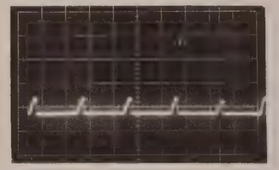
Figure 6-6. Driver.


AUTO GAIN CIRCUIT
AMPLIFIER
CLAMP
GATE GENERATOR
DOWN DRIVER
UP DRIVER
BALANCE
+12V
+17V
-18V
-12V
COM
IN AC AC RAT (AC RATIO) -18V COM
DECIMAL OUTPUTS FROM 10K DECADE
1 2 3 4 5 6 7 8 9
TR (TRIGGER)
GATE
+17V
UP 1 UP 2 DOWN 2 DOWN 1
NOTES:
1. ALL RESISTORS ARE 5%, 1/4W UNLESS NOTED OTHERWISE.
2. ALL DIODES ARE CD62 UNLESS NOTED OTHERWISE.
3. ALL TRANSISTORS ARE 2N404A UNLESS NOTED OTHERWISE.
4. ALL CAPACITORS IN μF UNLESS NOTED OTHERWISE.
5. RESISTORS SHOWN AS ±1% ARE 1/8W.
6. PARTIAL REFERENCE DESIGNATIONS SHOWN. ALL NUMBERS ARE IN SERIES 7701 AND ON. FOR COMPLETE DESIGNATION ADD 7700 TO DIGITS SHOWN. EXAMPLE: R1 IS R7701.

Schematic 7. Driver.

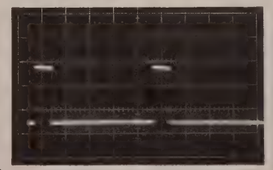


TP (12) SCOPE SETTING
VERTICAL SENSITIVITY 0.1uV/cm
HORIZONTAL SWEEP 2ms/cm

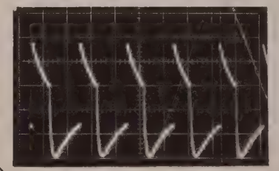


TP (13) SCOPE SETTING
VERTICAL SENSITIVITY 0.5V/cm
HORIZONTAL SWEEP 5ms/cm

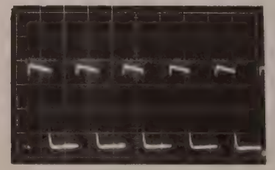
TP (14) A SCOPE SETTING
VERTICAL SENSITIVITY 5V/cm
HORIZONTAL SWEEP 0.2ms/cm



TP (14) B SCOPE SETTING
VERTICAL SENSITIVITY 5V/cm
HORIZONTAL SWEEP 3ms/cm



TP (15) SCOPE SETTING
VERTICAL SENSITIVITY 2V/cm
HORIZONTAL SWEEP 5ms/cm



TP (16) SCOPE SETTING
VERTICAL SENSITIVITY 2V/cm
HORIZONTAL SWEEP 5ms/cm

STANDARD DECADE

ASSEMBLY 90-6047

PARTS LIST

ASSEMBLY: Standard Decade CIMRON PART NO. 90-6047

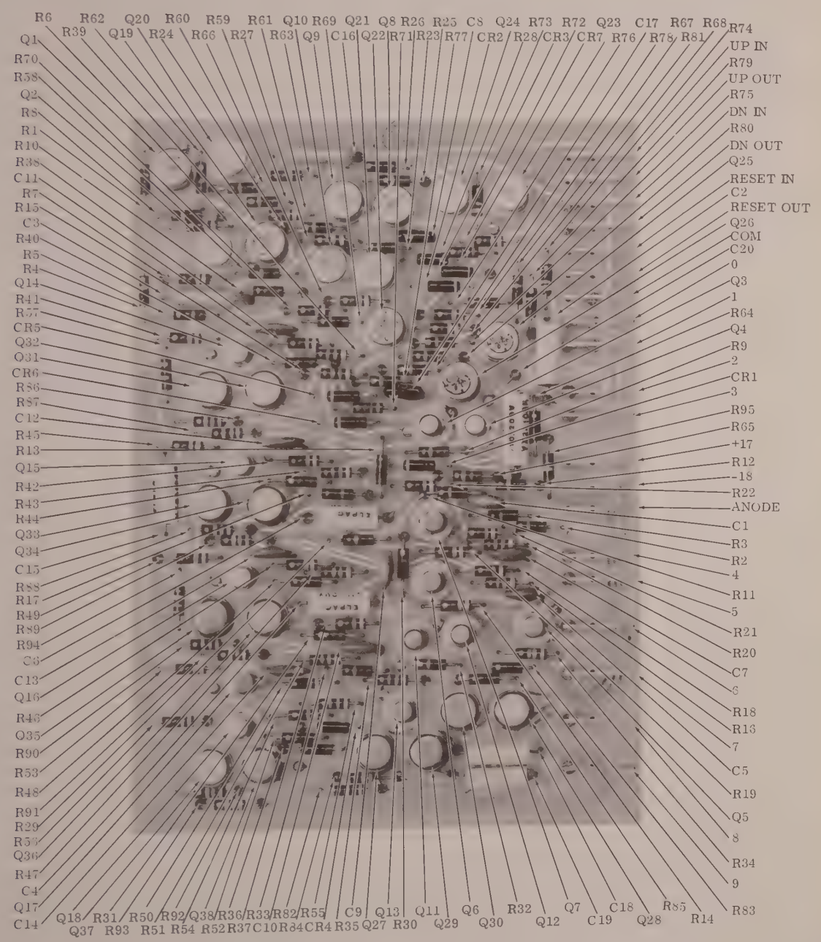
SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
RESISTOR (Cont'd)						
R4771	3.3KΩ	COMP	1/4W 5%	01121	CB-3325	7-41249
R4772 - R4774	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4775 - R4778	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R4779 - R4781	15KΩ	COMP	1/4W 5%	01121	CB-1535	7-41257
R4782	470KΩ	COMP	1/4W 5%	01121	CB-4745	7-41275
R4783	1KΩ	COMP	1/4W 5%	01121	CB-1025	7-41243
R4784	470KΩ	COMP	1/4W 5%	01121	CB-4745	7-41275
R4785	1KΩ	COMP	1/4W 5%	01121	CB-1025	7-41243
R4786 - R4793	470KΩ	COMP	1/4W 5%	01121	CB-4745	7-41275
R4794	330KΩ	COMP	1/4W 5%	01121	CB-3345	7-41273
R4795	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
SEMICONDUCTOR						
CR4701 - CR4707		**CD-61		15318		7-95511
TRANSISTOR						
Q4701		4JD7A35		15318		9-04718
Q4702		2N404A		JEDEC	2N404A	9-04609
Q4703, Q4704		**CT-26		15318		9-04710
Q4705 - Q4707		SILICON CONTROLLED SWITCH		JEDEC	3N83	9-04401
Q4708, Q4709		4JD7A35		15318		9-04718
Q4710		2N404A		JEDEC	2N404A	9-04609
Q4711, Q4712		**CT-26		15318		9-04710
Q4713 - Q4718		SILICON CONTROLLED SWITCH		JEDEC	3N83	9-04401
Q4719		4JD7A35		15318		9-04718
Q4720 - Q4724		2N404A		JEDEC	2N404A	9-04609
Q4725, Q4726		4JD7A35		15318		9-04718
Q4727 - Q4738		**CT-25		15318		9-04709
MISCELLANEOUS						
		ETCHED BOARD, STANDARD DECADE		15318		90-7047-1

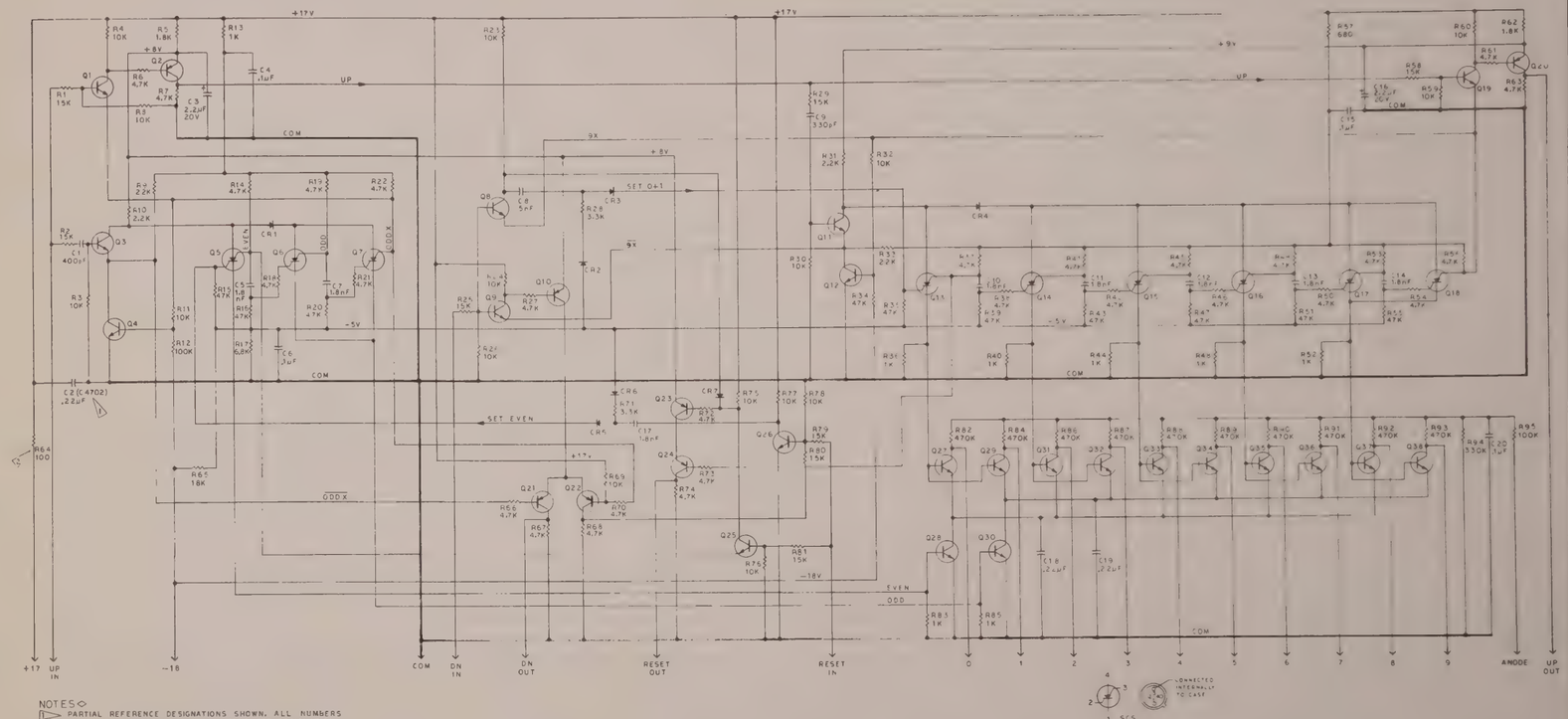
NOTE

**CD-61, I_f = 1V greater than 100 ma, I_r = 75V less than 1 ua, SILICON

**CT-25 = 2N3114

**CT-26 = 2N2222





NOTES:
1. PARTIAL REFERENCE DESIGNATIONS SHOWN, ALL NUMBERS ARE IN SERIES 4701 AND ON. FOR COMPLETE DESIGNATION ADD 4700 TO DIGITS SHOWN. EXAMPLE: C2 IS C4702
2. EXCEPT AS NOTED, RESISTORS ARE ±5% TOLERANCE, 1/4 WATT.

Schematic 8. Decade.

TEN THOUSAND DECADE

ASSEMBLY 90-6048

PARTS LIST

ASSEMBLY: 10K Decade CIMRON PART NO. 90-6048

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
CAPACITOR						
C4801	25uf	ELECT	25V 85°C	14655	NLW25-25	1-57223
C4802	1.8nf	DISC	1000V 10%	71590	DD-182	1-57503
C4803	.005uf	DISC	50V	71590	CK-502	1-57512
C4804	220pf	DISC	1000V 10%	71590	DD-221	1-57509
C4805	.1uf	MET PAP	50V 10%	12406	VX5A104K	1-57321
C4806 - C4815	1.8nf	DISC	1000V 10%	71590	DD-182	1-57503
C4816	.1uf	MET PAP	200V 10%	12406	VX2A104K	1-57340
RESISTOR						
R4801	15KΩ	COMP	1/4W 5%	01121	CB-1535	7-41257
R4802	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R4803	15KΩ	COMP	1/4W 5%	01121	CB-1535	7-41257
R4804 - R4806	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R4807	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R4808	33KΩ	COMP	1/4W 5%	01121	CB-3335	7-41261
R4809 - R4817	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4818	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R4819, R4820	15KΩ	COMP	1/4W 5%	01121	CB-1535	7-41257
R4821	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R4822	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4823	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R4824, R4825	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4826	1.8KΩ	COMP	1/4W 5%	01121	CB-1825	7-41246
R4827	2.2KΩ	COMP	1/4W 5%	01121	CB-2225	7-41247
R4828	15KΩ	COMP	1/4W 5%	01121	CB-1535	7-41257
R4829, R4830	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R4831	33KΩ	COMP	1/4W 5%	01121	CB-3335	7-41261
R4832	15KΩ	COMP	1/4W 5%	01121	CB-1535	7-41257
R4833	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R4834	150KΩ	COMP	1/4W 5%	01121	CB-1545	7-41269
R4835	18KΩ	COMP	1/4W 5%	01121	CB-1835	7-41258
R4836	6.8KΩ	COMP	1/4W 5%	01121	CB-6825	7-41253
R4837	33KΩ	COMP	1/4W 5%	01121	CB-3335	7-41261
R4838	47KΩ	COMP	1/4W 5%	01121	CB-4735	7-41263
R4839	68KΩ	COMP	1/4W 5%	01121	CB-6835	7-41265
R4840	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251

PARTS LIST

ASSEMBLY: 10K Decade CIMRON PART NO. 90-6048

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		CIMRON PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
RESISTOR (Cont'd)						
R4841	47KΩ	COMP	1/4W 5%	01121	CB-4735	7-41263
R4842	68KΩ	COMP	1/4W 5%	01121	CB-6835	7-41265
R4843	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4844	47KΩ	COMP	1/4W 5%	01121	CB-4735	7-41263
R4845	68KΩ	COMP	1/4W 5%	01121	CB-6835	7-41265
R4846	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4847	47KΩ	COMP	1/4W 5%	01121	CB-4735	7-41263
R4848	68KΩ	COMP	1/4W 5%	01121	CB-6835	7-41265
R4849	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4850	47KΩ	COMP	1/4W 5%	01121	CB-4735	7-41263
R4851	68KΩ	COMP	1/4W 5%	01121	CB-6835	7-41265
R4852	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4853	47KΩ	COMP	1/4W 5%	01121	CB-4735	7-41263
R4854	68KΩ	COMP	1/4W 5%	01121	CB-6835	7-41265
R4855	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4856	47KΩ	COMP	1/4W 5%	01121	CB-4735	7-41263
R4857	68KΩ	COMP	1/4W 5%	01121	CB-6835	7-41265
R4858	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4859	47KΩ	COMP	1/4W 5%	01121	CB-4735	7-41263
R4860	68KΩ	COMP	1/4W 5%	01121	CB-6835	7-41265
R4861	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4862	47KΩ	COMP	1/4W 5%	01121	CB-4735	7-41263
R4863	68KΩ	COMP	1/4W 5%	01121	CB-6835	7-41265
R4864	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4865	47KΩ	COMP	1/4W 5%	01121	CB-4735	7-41263
R4866	68KΩ	COMP	1/4W 5%	01121	CB-6835	7-41265
R4867	56KΩ	COMP	1/4W 5%	01121	CB-5635	7-41264
R4868	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4869	220KΩ	COMP	1/4W 5%	01121	CB-2245	7-41271
R4870	68KΩ	COMP	1/4W 5%	01121	CB-6835	7-41265
R4871	470KΩ	COMP	1/4W 5%	01121	CB-4745	7-41275

PARTS LIST

ASSEMBLY: 10K Decade CIMRON PART NO. 90-6048

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
SEMICONDUCTOR						
CR4801 - CR4803		**CD-62 DIODE		15318		7-95507
CR4804, CR4805		**CD-61 DIODE		15318		7-95511
CR4806 - CR4810		**CD-62 DIODE		15318		7-95507
CR4811, CR4812		**CD-61 DIODE		15318		7-95511
TRANSISTOR						
Q4801, Q4802		4JD7A35		15318		9-04718
Q4803 - Q4806		2N404A		JEDEC	2N404A	9-04609
Q4807		**CT-26		15318		9-04710
Q4808		4JD7A35		15318		9-04718
Q4809		2N404A		JEDEC	2N404A	9-04609
Q4810 - Q4812		**CT-26		15318		9-04710
Q4813 - Q4823		SILICON CONTROLLED SWITCH		JEDEC	3N83	9-04401
MISCELLANEOUS						
		ETCHED BOARD, 10K DECADE		15318		90-7048-1

NOTE

**CD-61, I_f = 1V greater than 100 ma, I_r = 75V less than 1 ua, SILICON

**CD-62, I_f = 1V greater than 100 ma, I_r = 300V less than 6 ua, SILICON

**CT-26 = 2N2222

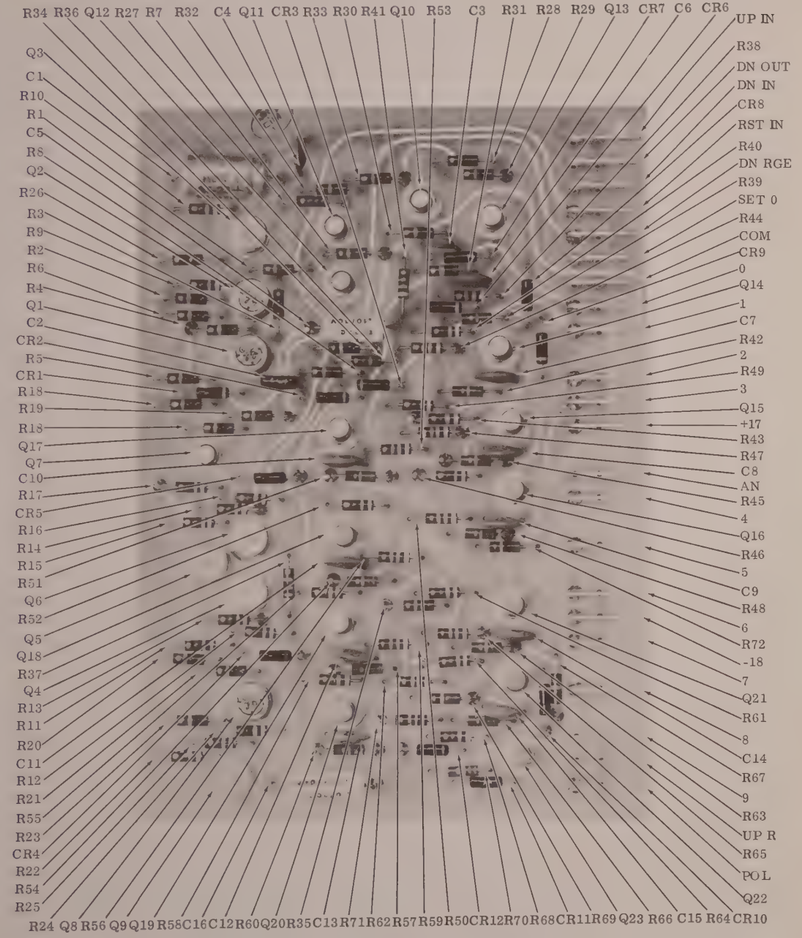
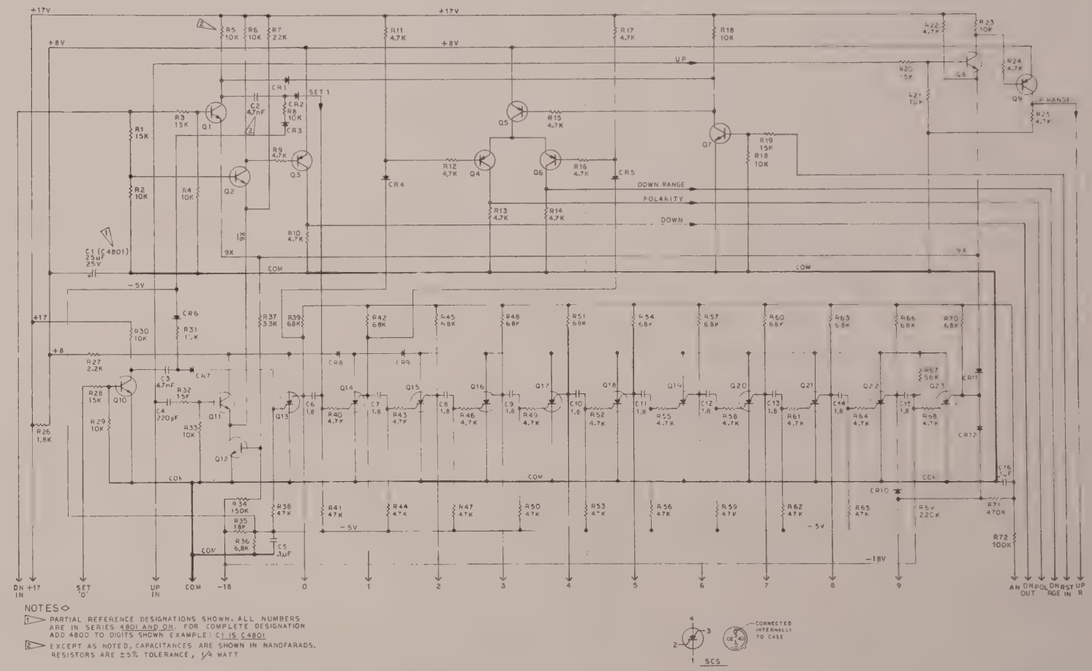


Figure 6-8. 10K Decade.



Schematic 9. 10K Decade.

RANGE AND POLARITY

ASSEMBLY 90-6046

PARTS LIST

ASSEMBLY: Range and Polarity CIMRON PART NO. 90-6046

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		CIMRON PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
CAPACITOR						
C4601, C4602	1uf	MET PAP	50V 10%	12406	VX5A105K	1-57317
C4603	5uf	MET PAP	100V 20%	12406	VX1A505	1-57313
C4604	5uf	ELECT	50V	14655	NLW 5-50	1-57255
C4605	1.8nf	DISC	1000V 10%	71590	DD-182	1-57503
C4606	.22uf	MET PAP	50V 10%	12406	VX5A224K	1-57319
C4607	1.8nf	DISC	1000V 10%	71590	DD-182	1-57503
C4608, C4609	10nf	MET MY	200V 10%	14752	215BIC103K2	1-57355
C4610	.1uf	MET PAP	50V 10%	12406	VX5A104K	1-57321
C4611	4.7uf	MET MY	200V 10%	14752	215BIC472K2	1-57353
RESISTOR						
R4601, R4602	47KΩ	COMP	1/4W 5%	01121	CB-4735	7-41263
R4603	270KΩ	COMP	1/4W 5%	01121	CB-2745	7-41272
R4604	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4605	470Ω	COMP	1/4W 5%	01121	CB-4715	7-41239
R4606	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4607	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R4608	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R4609	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R4610	3.3KΩ	COMP	1/4W 5%	01121	CB-3325	7-41249
R4611	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R4612	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R4613, R4614	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4615, R4616	2.7KΩ	COMP	1/4W 5%	01121	CB-2725	7-41248
R4617	15KΩ	COMP	1/4W 5%	01121	CB-1535	7-41257
R4618, R4619	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R4620, R4621	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4622	1KΩ	COMP	1/4W 5%	01121	CB-1025	7-41243
R4623	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R4624, R4625	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R4626	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4627	56KΩ	COMP	1/4W 5%	01121	CB-5635	7-41264
R4628	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R4629	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R4630	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4631	56KΩ	COMP	1/4W 5%	01121	CB-5635	7-41264

PARTS LIST

ASSEMBLY: Range and Polarity CIMRON PART NO. 90-6046

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
RESISTOR (Cont'd)						
R4632	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R4633	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R4634	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4635, R4636	56KΩ	COMP	1/4W 5%	01121	CB-5635	7-41264
R4637, R4638	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4639	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R4640	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4641	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R4642	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R4643	56KΩ	COMP	1/4W 5%	01121	CB-5635	7-41264
R4644	150KΩ	COMP	1/4W 5%	01121	CB-1545	7-41269
R4645	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R4646	33KΩ	COMP	1/4W 5%	01121	CB-3335	7-41261
R4647	270KΩ	COMP	1/4W 5%	01121	CB-2745	7-41272
R4648	33KΩ	COMP	1/4W 5%	01121	CB-3335	7-41261
R4649	270KΩ	COMP	1/4W 5%	01121	CB-2745	7-41272
R4650	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R4651	47KΩ	COMP	1/4W 5%	01121	CB-4735	7-41263
R4652	1MΩ	COMP	1/4W 5%	01121	CB-1055	7-41279
R4653	1KΩ	COMP	1/4W 5%	01121	CB-1025	7-41243
R4654	33KΩ	COMP	1/4W 5%	01121	CB-3335	7-41261
R4655	100Ω	COMP	1/4W 5%	01121	CB-1015	7-41231
SEMICONDUCTOR						
CR4601 - CR4606		**CD-61 DIODE		15318		7-95511
CR4607		ZENER 1N714A		JEDEC	1N714A	7-95630
CR4608 - CR4616		**CD-61 DIODE		15318		7-95511
CR4617		**CD-62 DIODE		15318		7-95507
CR4618		**CD-61 DIODE		15318		7-95511
CR4619		**CD-62 DIODE		15318		7-95507
CR4620 - CR4623		**CD-61 DIODE		15318		7-95511
CR4624		**CD-62 DIODE		15318		7-95507
CR4625		**CD-61 DIODE		15318		7-95511
CR4626		**CD-62 DIODE		15318		7-95507
CR4627 - CR4630		**CD-61 DIODE		15318		7-95511

PARTS LIST

ASSEMBLY: Range and Polarity CIMRON PART NO. 90-6046

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
TRANSISTOR						
Q4601		2N2647		JEDEC	2N2647	9-04400
Q4602 - Q4604		**CT-20		15318		9-04701
Q4605		2N1304		JEDEC		9-04500
Q4606		2N404A		JEDEC	2N404A	9-04609
Q4607 - Q4609		**CT-20		15318		9-04701
Q4610, Q4611		**CT-25		15318		9-04709
Q4612, Q4613		**CT-20		15318		9-04701
Q4614		2N2647		JEDEC	2N2647	9-04400
REED						
S4601		MR-306-8		95348	MR-306-8	7-38216
COIL						
L4601		REED SWITCH ACTUATOR		15318		50-0501-1
MISCELLANEOUS						
		ETCHED BOARD, RANGE AND POLARITY		15318		90-7046-1
		SHIELD ASSEMBLY, RANGE AND POLARITY		15318		80-2000-3

NOTE

**CD-61, I_f = 1V greater than 100 ma, I_r = 75 V less than 1 ua, SILICON

**CD-62, I_f = 1V greater than 100 ma, I_r = 300V less than 6 ua, SILICON

**CT-20 = 2N697

**CT-25 = 2N3114

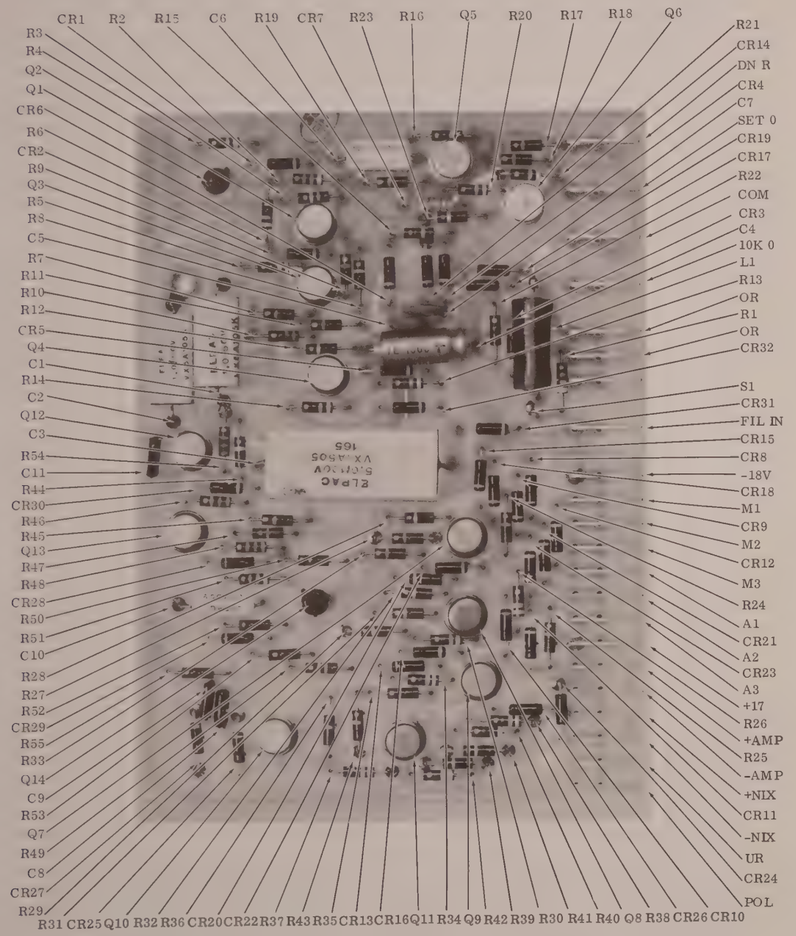
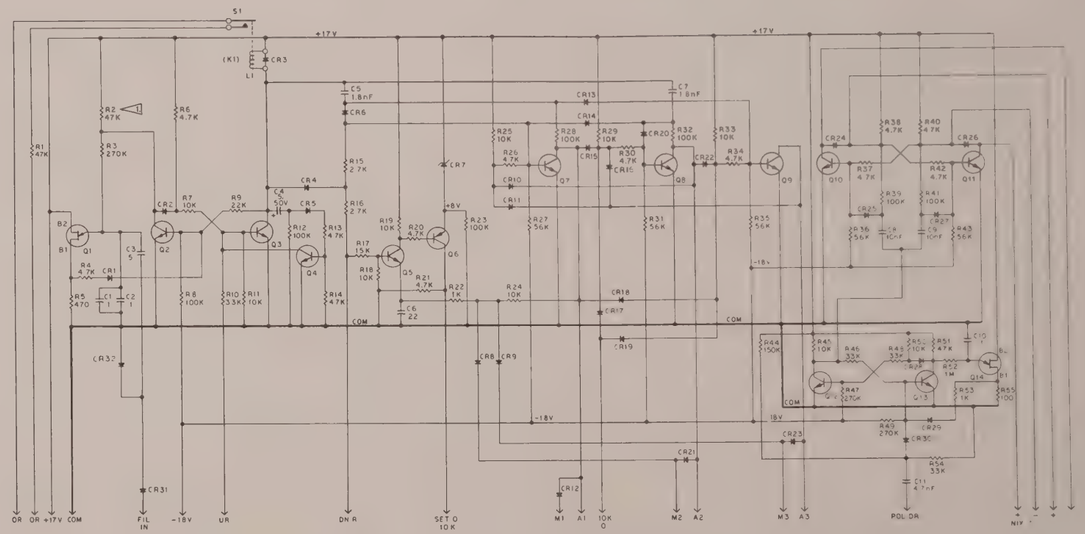


Figure 6-9. Range and Polarity.



NOTES ◇

1. PARTIAL REFERENCE DESIGNATIONS SHOWN. ALL NUMBERS ARE IN SERIES 4601 AND ON. FOR COMPLETE DESIGNATION ADD 4600 TO DIGITS SHOWN. EXAMPLE: R2 IS R4602
2. ALL RESISTORS ARE 1/4W & ±5% TOLERANCE
3. ALL CAPACITORS ARE IN μF UNLESS NOTED OTHERWISE.

Schematic 10. Range and Polarity.

REFERENCE

ASSEMBLY 90-6049

PARTS LIST

ASSEMBLY: Reference CIMRON PART NO. 90-6049

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
CAPACITOR						
C4901, C4902	50uf	ELECT	50V 85°	14655	NLW 50-50	1-57257
C4903	1uf	MET MY	200V	12406	ZD-2130	1-57308
RESISTOR						
*R4901 - R4903						
R4904	5KΩ	VAR TRIM WW		80294	275-1-502	7-54207
R4905	100Ω	VAR TRIM WW		80294	275-1-101	7-54212
SEMICONDUCTOR						
CR4901, CR4902		SC-2 DIODE		14099	SC-2	7-95502
CR4903		**CD-61 DIODE		15318		7-95511
CR4904		**CD-62 DIODE		15318		7-95507
SOLENOID						
K4901		3PDT (PRINTACT) RELAY		21226	18-BW3-G	7-38214
MISCELLANEOUS						
		ETCH BOARD, REFERENCE		15318		90-7049-1A
		SHIELD ASSEMBLY, REFERENCE		15318		80-2000-3
Z4901, Z4902		KIT, MODULE		15318		90-0509

NOTE

**CD-61, I_f = 1V greater than 100 ma, I_r = 75V less than 1 ua, SILICON

**CD-62, I_f = 1V greater than 100 ma, I_r = 300V less than 6 ua, SILICON

*Selected Value

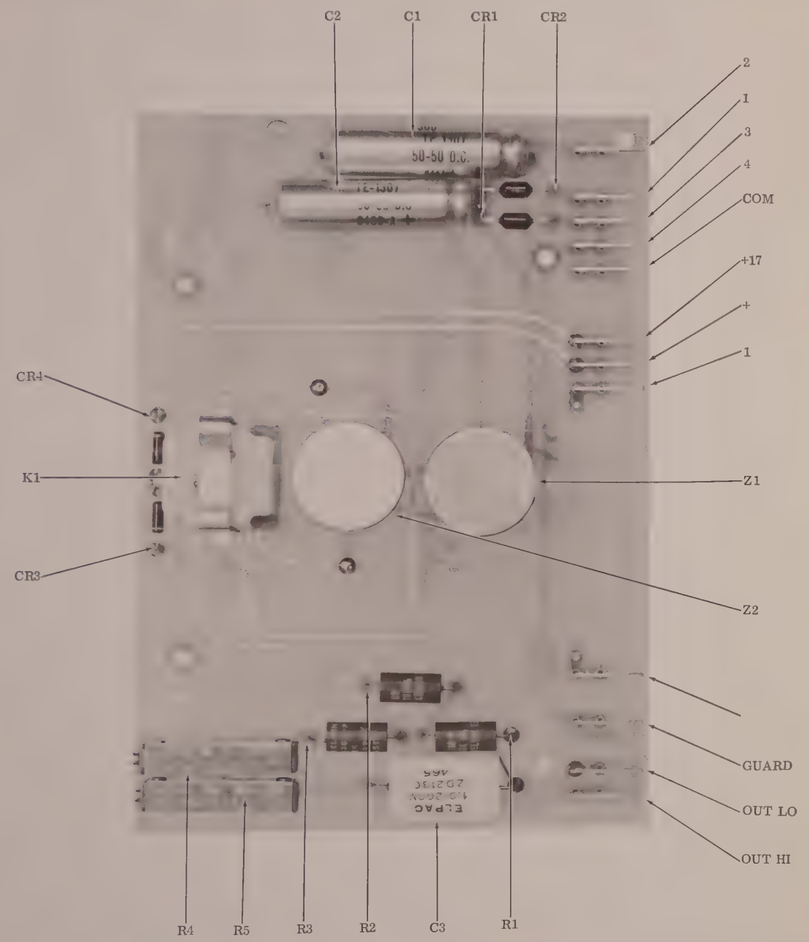
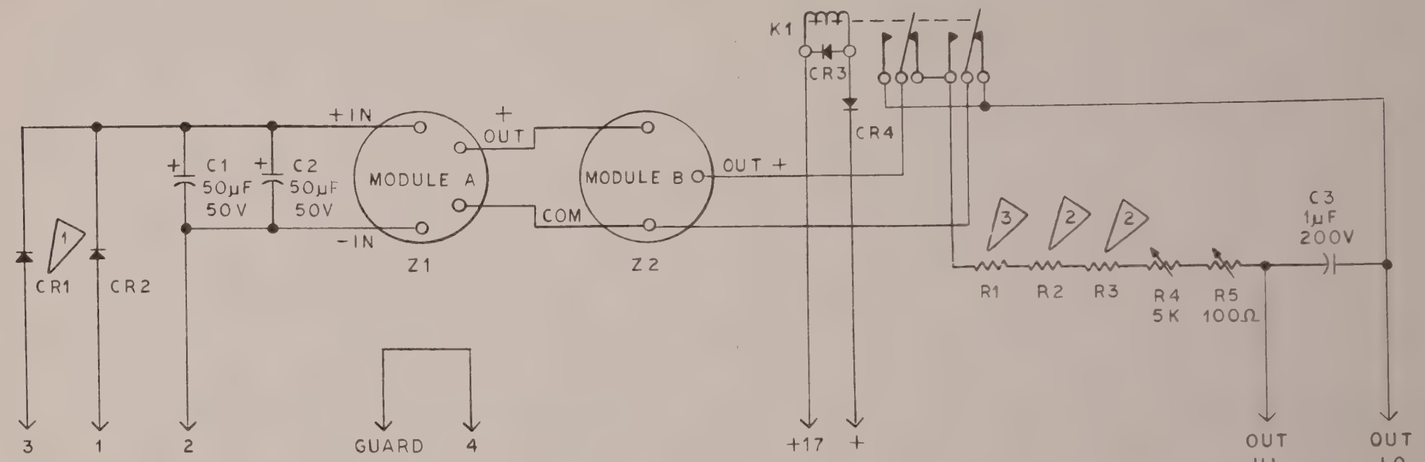


Figure 6-10. Reference.



NOTES ⟨

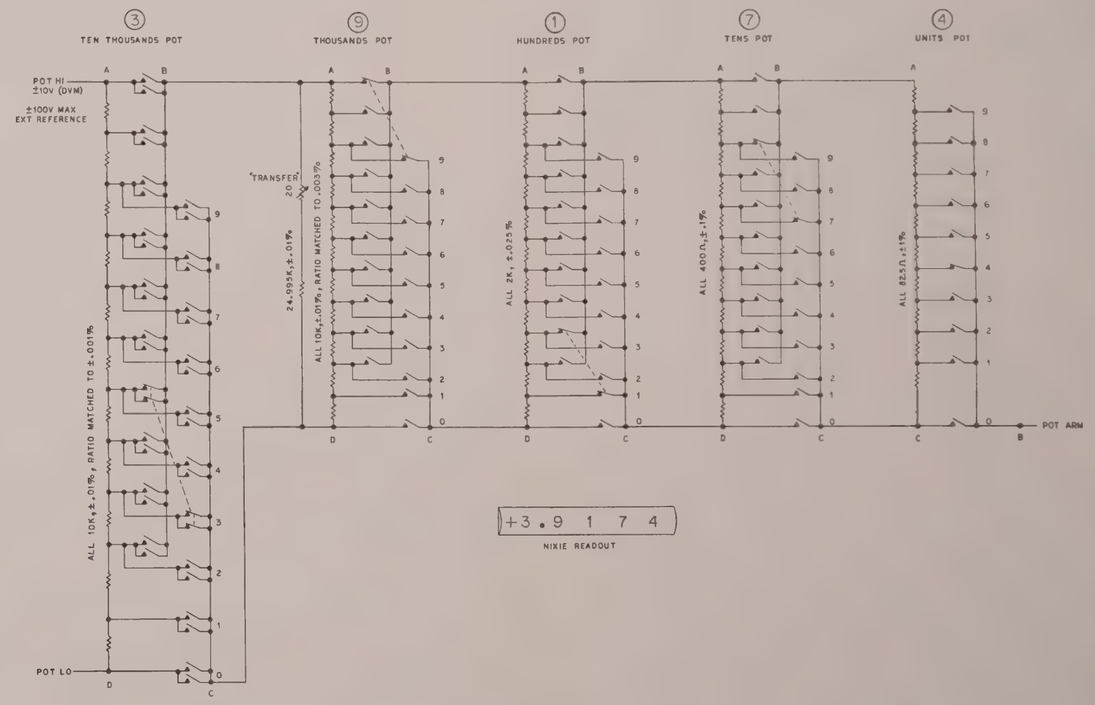
1. PARTIAL REFERENCE DESIGNATIONS SHOWN. ALL NUMBERS ARE IN THE SERIES 4901 & ON. EXAMPLE: CR1 IS CR4901, ETC.

2. RESISTANCE VALUES OF R4902 & R4903 SELECTED RELATIVE TO THE OUTPUT VOLTAGE OF MODULE "B" — SEE TABLE.

3. FACTORY SELECTED VALUE. (NORMALLY JUMPERED)

OUTPUT VOLTAGE OF Z4902	RESISTOR VALUES	
	R4902	R4903
11.90-12.10	10K	7.5K
12.10-12.40	10K	10K
12.40-12.60	20K	2K
12.60-12.90	20K	5K
12.90-13.23	20K	7.5K

Schematic 11. Reference.



Schematic #12. Potentiometer Block Diagram.

10K POTENTIOMETER

ASSEMBLY 90-6058

PARTS LIST

ASSEMBLY: 10K's Potentiometer CIMRON PART NO. 90-6058

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		CIMRON PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
RESISTOR						
*R901 - R911	10KΩ	WW	0.01%	05347	305A	5-40012*
SEMICONDUCTOR						
CR901 - CR910		**CD-61 DIODE		15318		7-95511
CR911 - CR920		**CD-62 DIODE		15318		7-95507
REED						
S901 - S920		RELAY, SPST, GOLD		12617	MRG-1	7-38207
COIL						
L901 - L920		REED SWITCH ACTUATOR		15318		80-0501-1
MISCELLANEOUS						
		SHIELD ASSEMBLY		15318		90-3049-1
		ETCHED BOARD, 10K POT A		15318		90-7056-1
		ETCHED BOARD, 10K POT B				90-7057-1

NOTE

*These resistors are ratio-matched to 0.001% and must be replaced as one unit under part number 5-40012.

**CD-61, I_f = 1V greater than 100 ma, I_r = 75V less than 1 ua, SILICON

**CD-62, I_f = 1V greater than 100 ma, I_r = 300V less than 6 ua, SILICON

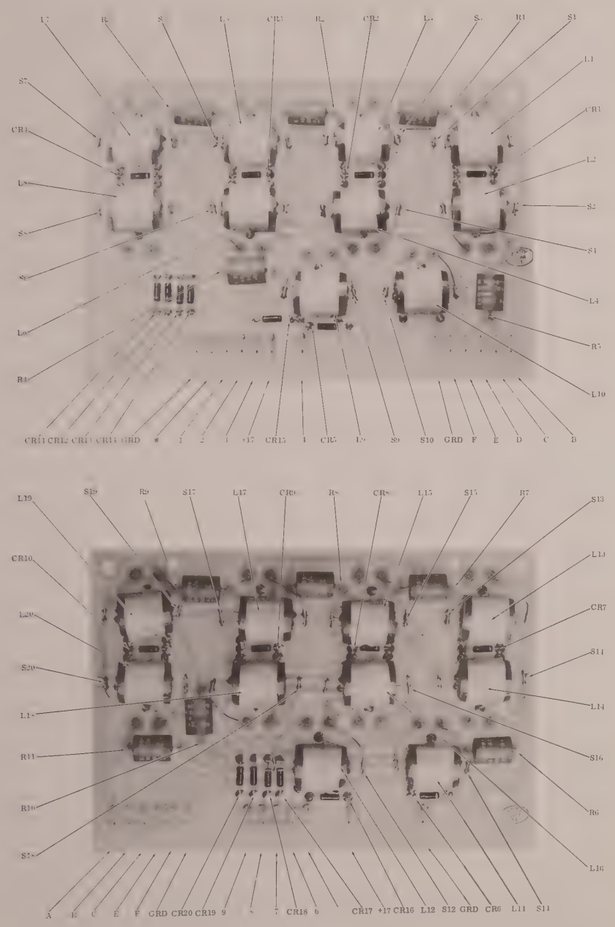
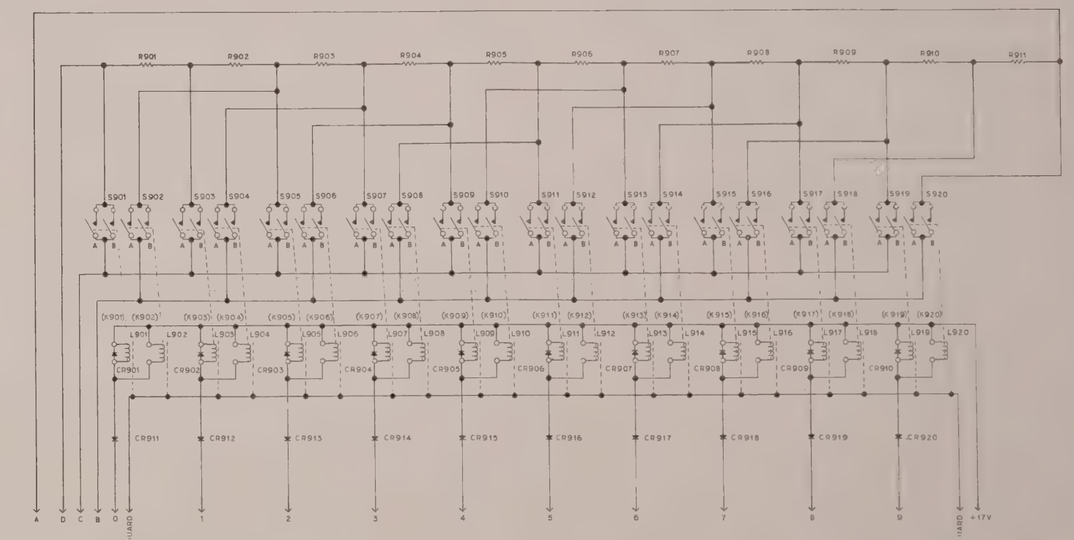


Figure 6-11. 10K Pot.



NOTES ◇

1. UNLESS OTHERWISE NOTED RESISTORS ARE 10K, 1/4W, & ± .01% TOLERANCE, MATCHED TO .001%.
2. CR901 THRU CR910 ARE CD-61; CR911 THRU CR920 ARE CD-62.

CAUTION IN ORDER TO ASSURE LOW LEAKAGE USE **CLEAN NYLON GLOVES** WHEN HANDLING THIS BOARD ASSY.

Schematic 13. 10K Pot.

13

THOUSANDS POTENTIOMETER

ASSEMBLY 90-6008

PARTS LIST

ASSEMBLY: 1000's Potentiometer CIMRON PART NO. 90-6008

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		CIMRON PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
RESISTOR						
*R801	24.995KΩ	WW	0.01%	15318		5-40013*
R802	20Ω	VAR TRIM WW	1W	09145	114-200	7-54214
*R803 - R813	10KΩ	WW	0.01%	15318		5-40013*
SEMICONDUCTOR						
CR801 - CR810		**CD-61 DIODE		15318		7-95511
CR811 - CR820		**CD-62 DIODE		15318		7-95507
REED						
S801A - S810A, S801B - S810B		RELAY		12617	MRG-1	7-38207
COIL						
L801 - L810		REED SWITCH ACTUATOR		15318		80-0501-1
MISCELLANEOUS						
		SHIELD ASSEMBLY, 1000's POT		15318		80-2000-1
		ETCHED BOARD, 1000's POT		15318		90-7008-1

NOTE

*These resistors are ratio-matched to 0.003% and must be replaced as one unit under part number 5-40013.

**CD-61, I_f = 1V greater than 100 ma, I_r = 75V less than 1 ua, SILICON

**CD-62, I_f = 1V greater than 100 ma, I_r = 300V less than 6 ua, SILICON

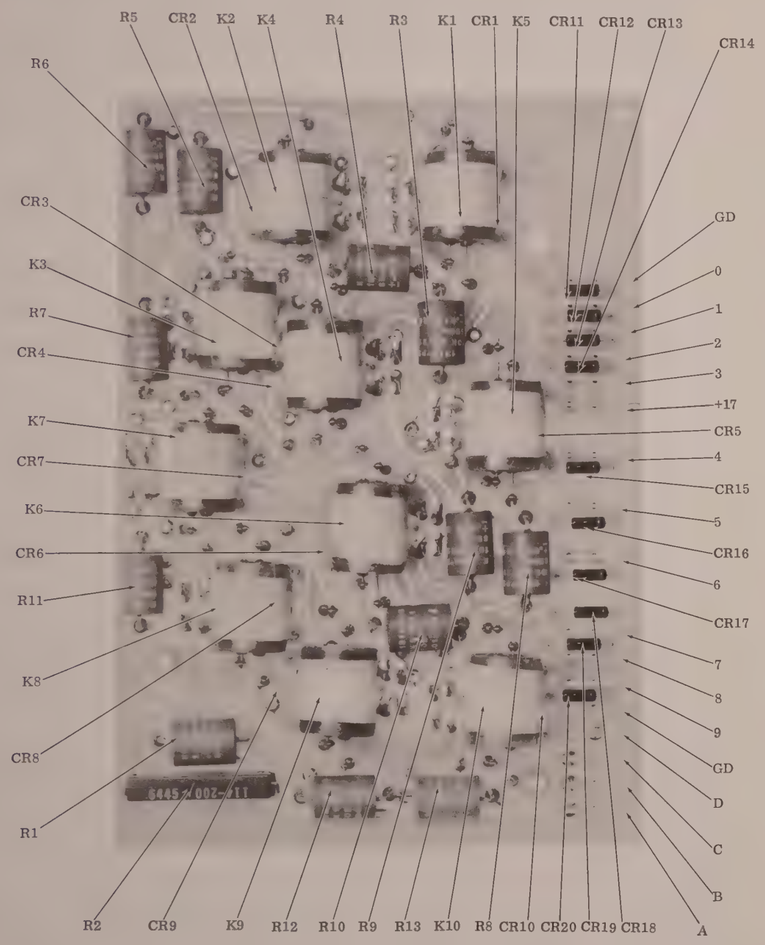
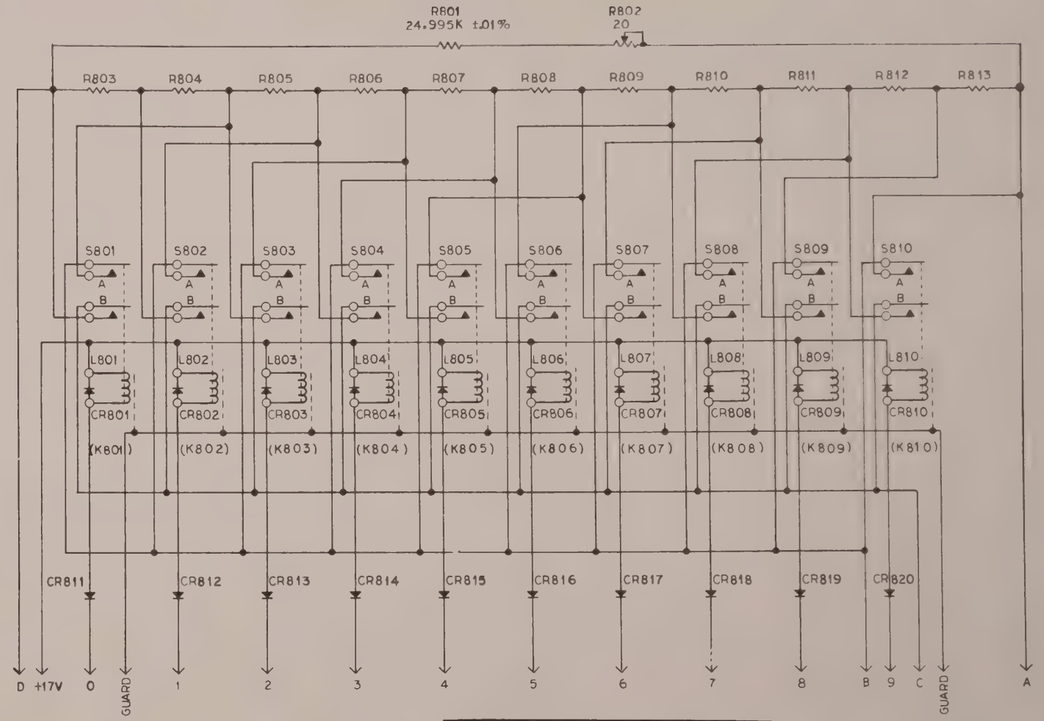


Figure 6-12. 1K Pot.



CAUTION IN ORDER TO ASSURE LOW LEAKAGE USE **CLEAN NYLON GLOVES** WHEN HANDLING THIS BOARD ASSY

NOTES◇

1. UNLESS OTHERWISE NOTED RESISTORS ARE 10K Ω, ±.01 TOLERANCE.
2. CR801 THRU CR810 ARE CD-61; CR811 THRU CR820 ARE CD-62.

Schematic 14. 1K Pot.

HUNDREDS POTENTIOMETER

ASSEMBLY 90-6007

PARTS LIST

ASSEMBLY: 100's Potentiometer CIMRON PART NO. 90-6007

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
RESISTOR						
*R701 - R711	2KΩ	WW	0.025%	15318		5-40014*
SEMICONDUCTOR						
CR701 - CR710		**CD-61 DIODE		15318		7-95511
CR711 - CR720		**CD-62 DIODE		15318		7-95507
REED						
S701A - S710A, S701B - S710B		RELAY		12617	MRG-1	7-38207
COIL						
L701 - L710		REED SWITCH ACTUATOR		15318		80-0501-1
MISCELLANEOUS						
		SHIELD ASSEMBLY, 100's POT		15318		80-2000-3
		ETCHED BOARD, 100's POT		15318		90-7007-1

NOTE

*These resistors must be replaced as one unit under part number 5-40014.

**CD-61, I_f = 1V greater than 100 ma, I_r = 75V less than 1 ua, SILICON

**CD-62, I_f = 1V greater than 100 ma, I_r = 300V less than 6 ua, SILICON

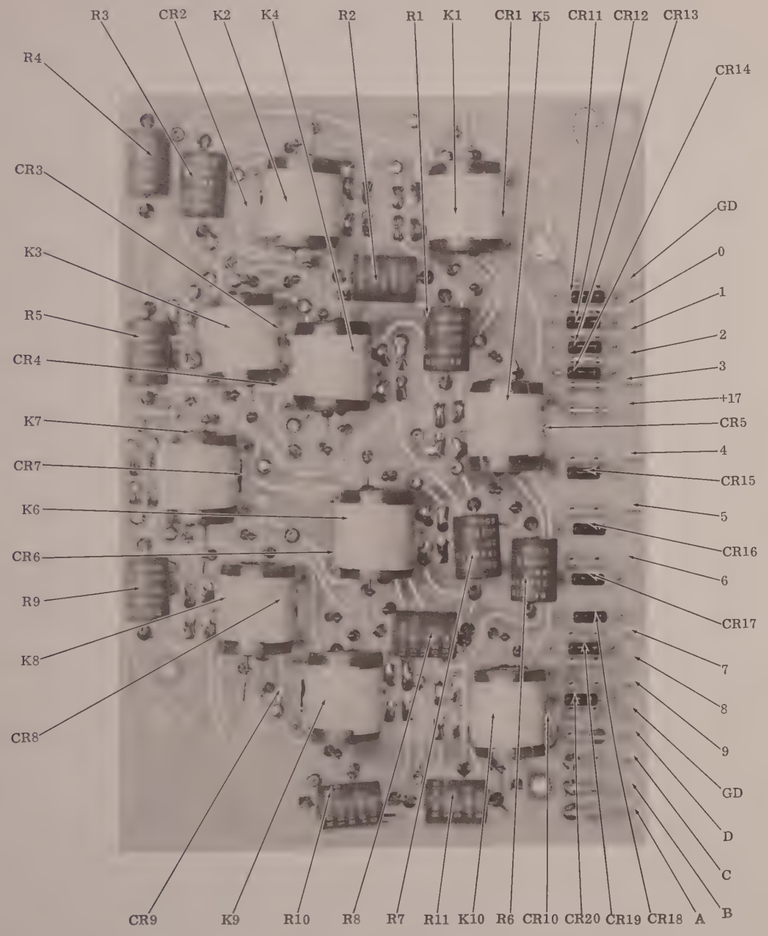
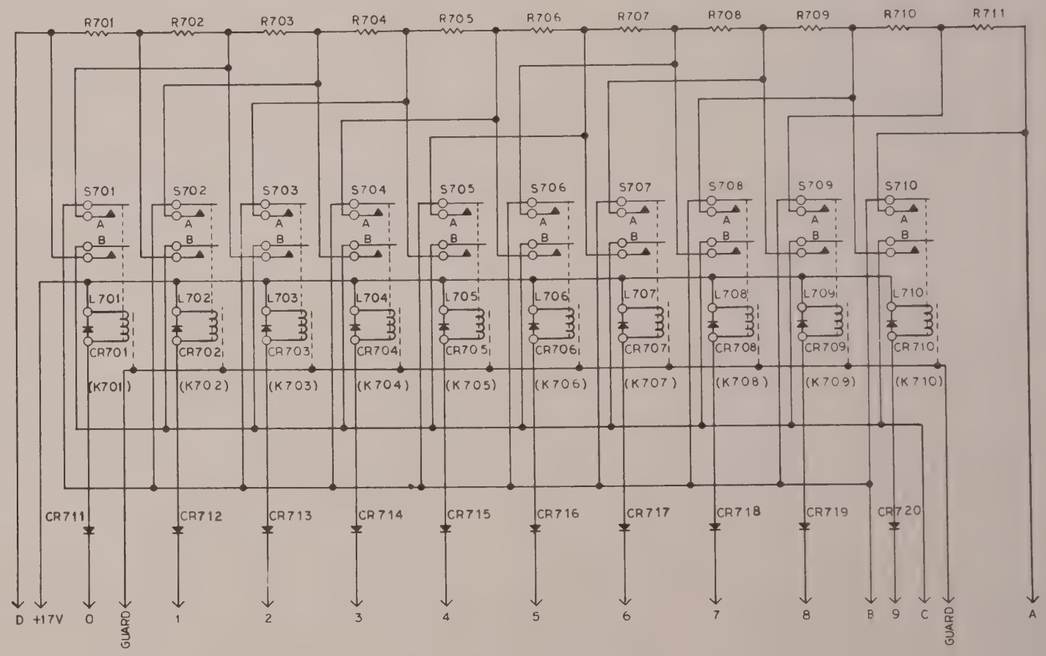


Figure 6-13. 100 Pot.



NOTES◇
1. UNLESS OTHERWISE NOTED RESISTORS ARE 2K ±.025%
2. CR701 THRU CR710 ARE CD-61; CR711 THRU CR720 ARE CD-62.

CAUTION IN ORDER TO ASSURE LOW LEAKAGE USE **CLEAN NYLON GLOVES** WHEN HANDLING THIS BOARD ASSY.

Schematic 15. 100 Pot.

TENS POTENTIOMETER

ASSEMBLY 90-6006

PARTS LIST

ASSEMBLY: 10's Potentiometer CIMRON PART NO. 90-6006

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
RESISTOR						
*R601-R611	400Ω	MET FILM	1/4W 0.1%	15318		5-40015*
SEMICONDUCTOR						
CR601 - CR610		**CD-61 DIODE		15318		7-95511
CR611 - CR620		**CD-62 DIODE		15318		7-95507
REED						
S601A - S610A, S601B - S610B		RELAY		12617	MRG - 1	7-38207
COIL						
L601 - L610		REED SWITCH ACTUATOR		15318		80-0501-1
MISCELLANEOUS						
		SHIELD ASSEMBLY, 10's POT		15318		80-2000-1
		ETCHED BOARD° 10's POT		15318		90-7006-1

NOTE

*These resistors must be replaced as one unit under part number 5-40015.

**CD-61, I_f = 1V greater than 100 ma, I_r = 75V less than 1 ua, SILICON

**CD-62, I_f = 1V greater than 100 ma, I_r = 300V less than 6 ua, SILICON

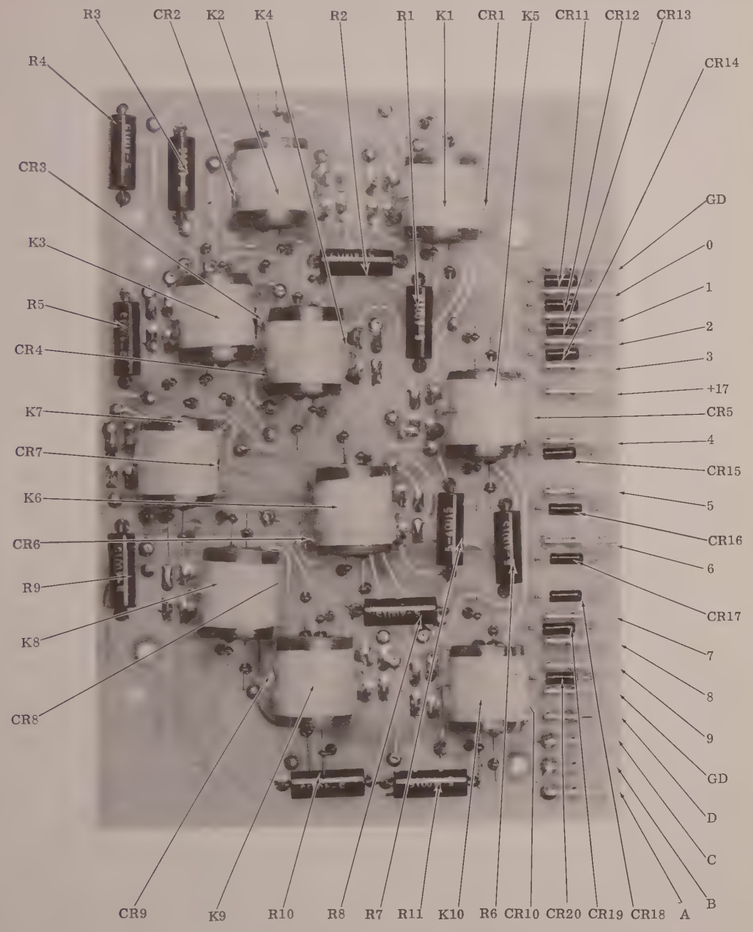
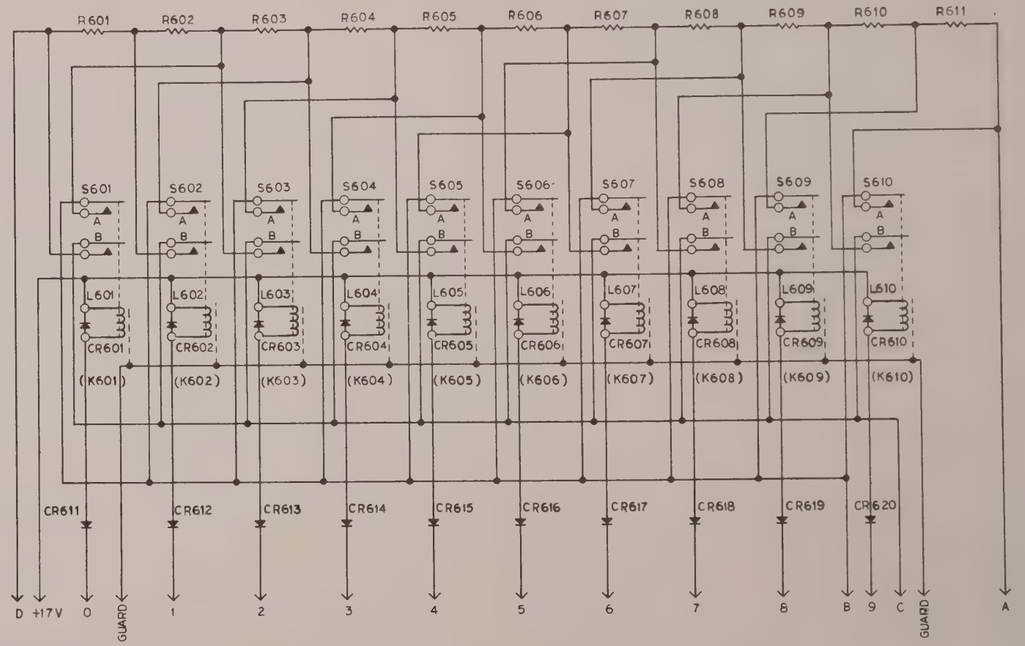


Figure 6-14. 10 Pot.



NOTES◇
1. UNLESS OTHERWISE NOTED RESISTORS ARE 400Ω, ±1% TOLERANCE.
2. CR601 THRU CR610 ARE CD-61; CR611 THRU CR620 ARE CD-62.

CAUTION IN ORDER TO ASSURE LOW LEAKAGE USE **CLEAN NYLON GLOVES** WHEN HANDLING THIS BOARD ASSY

Schematic 16. 10 Pot.

UNITS POTENTIOMETER

ASSEMBLY 90-6005

PARTS LIST

ASSEMBLY: Units Potentiometer CIMRON PART NO. 90-6005

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
RESISTOR						
*R501 - R510	82.5Ω	MET FILM	1/4W 1%	15318		5-40017*
SEMICONDUCTOR						
CR501 - CR510		**CD-61 DIODE		15318		7-95511
CR511 - CR520		**CD-62 DIODE		15318		7-95507
REED						
S501 - S510		RELAY		12617	MRG-1	7-38207
COIL						
L501 - L510		REED SWITCH ACTUATOR		15318		80-0502-1
MISCELLANEOUS						
		SHIELD ASSEMBLY, UNITS POT		15318		80-2000-3
		ETCHED BOARD, UNITS POT		15318		90-7005-1

NOTE

*These resistors must be replaced as one unit under part number 5-40017.

**CD-61, I_f = 1V greater than 100 ma, I_r = 75V less than 1 ua, SILICON

**CD-62, I_f = 1V greater than 100 ma, I_r = 300V less than 6 ua, SILICON

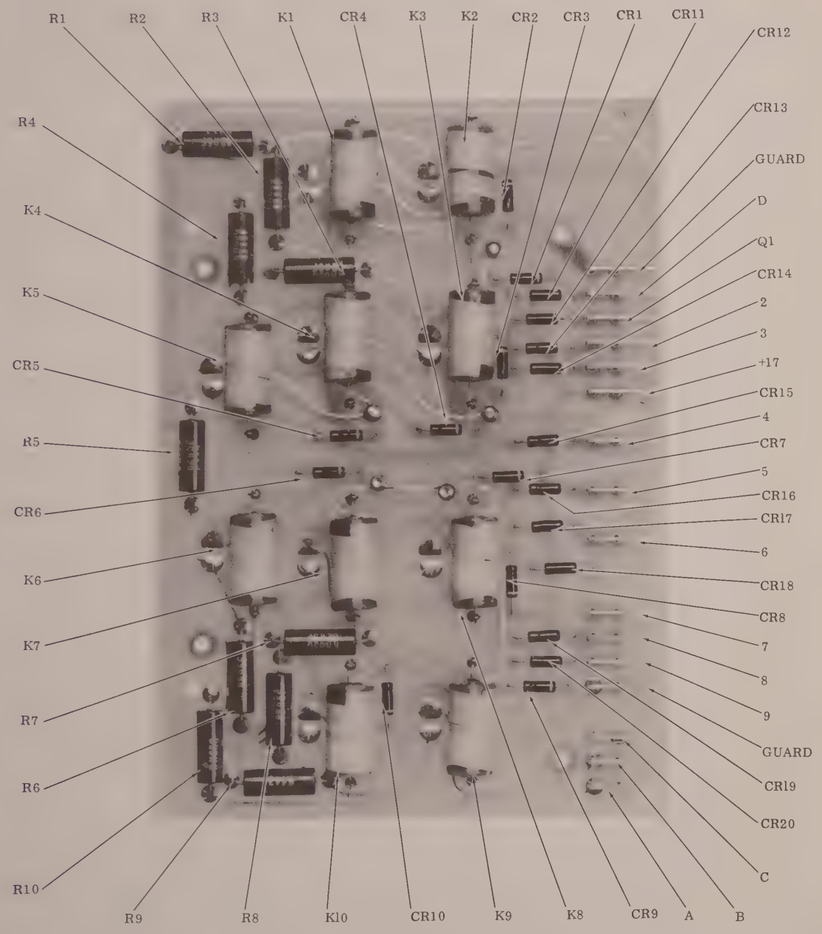
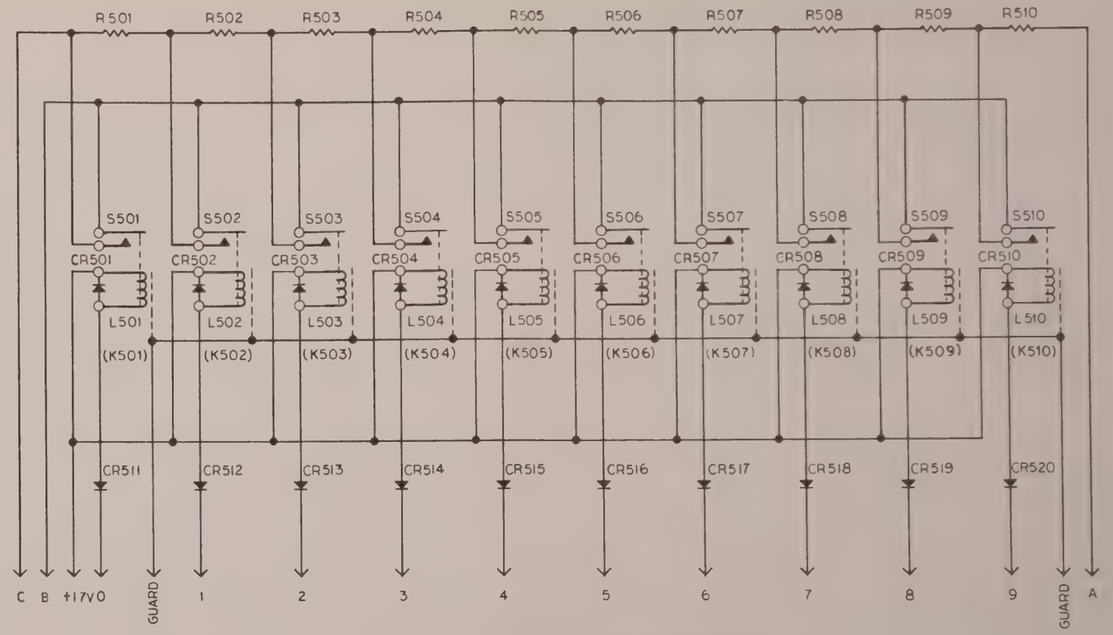


Figure 6-15. Units Pot.



CAUTION IN ORDER TO ASSURE LOW LEAKAGE USE **CLEAN NYLON GLOVES** WHEN HANDLING THIS BOARD ASSY.

NOTES◇

1. ALL RESISTORS ARE 82.5 Ω ± 1% TOLERANCE.
2. CR501 THRU CR510 ARE CD-61; CR511 THRU CR520 ARE CD-62.

Schematic 17. Units Pot.

FUNCTION RATIO

ASSEMBLY 90-6074

PARTS LIST

ASSEMBLY: FUNCTION RATIO CIMRON PART NO. 90-6074

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
RESISTOR						
R7401	47KΩ	COMP	1/2W 5%	01121	CB-4735	7-41063
R7402	180Ω	COMP	1/2W 5%	01121	CB-1815	7-41034
SEMICONDUCTOR						
CR7401 - CR7410		**CD-61 DIODE		15318		7-95511
CR7411 - CR7438		**CD-62 DIODE		15318		7-95507
SOLENOID						
K7401, K7402		RELAY PRINTED CIRCUIT 3PDT		21226	18-BW3-G	7-38214
REED						
S7401 - S7405		RELAY MR-306-8		95348	MR-306-8	7-38216
COIL						
L7401 - L7403		REED SWITCH ACTUATOR		15318		80-0501-1
L7404, L7405		REED SWITCH ACTUATOR		15318		50-0501-1
MISCELLANEOUS						
		SHIELD ASSEMBLY, FUNCTION RATIO		15318		80-2000-3
		ETCHED BOARD, FUNCTION RATIO		15318		90-7074-1A

NOTE

**CD-61, I_f = 1V greater than 100 ma, I_r = 75V less than 1 ua, SILICON

**CD-62, I_f = 1V greater than 100 ma, I_r = 300V less than 6 ua, SILICON

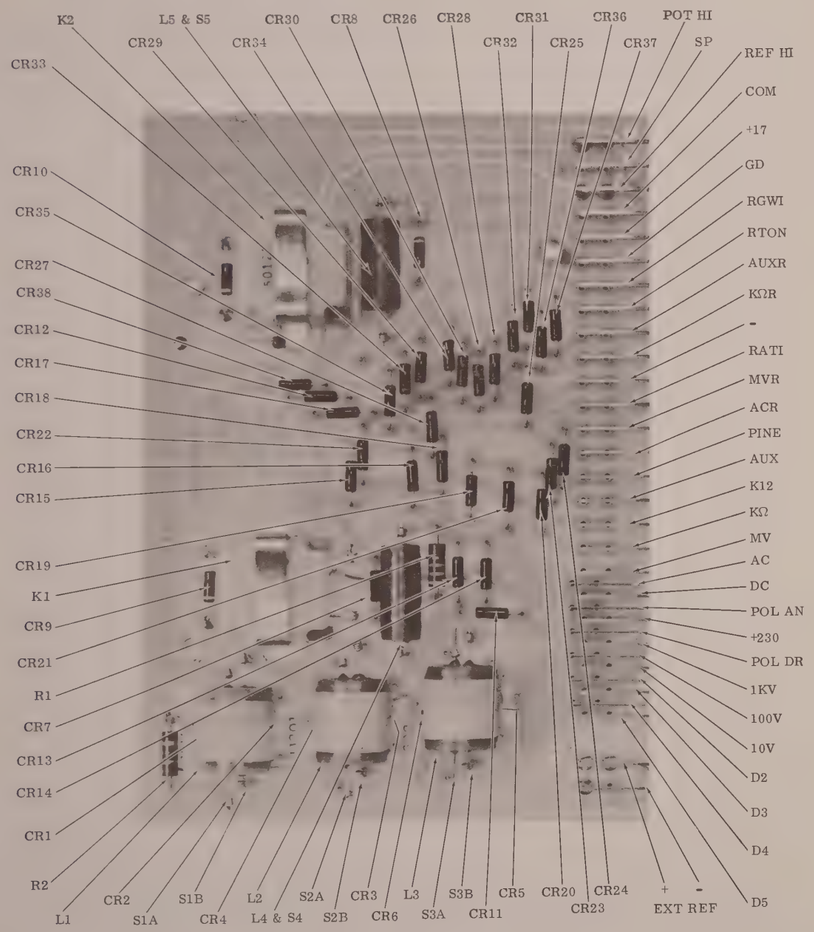
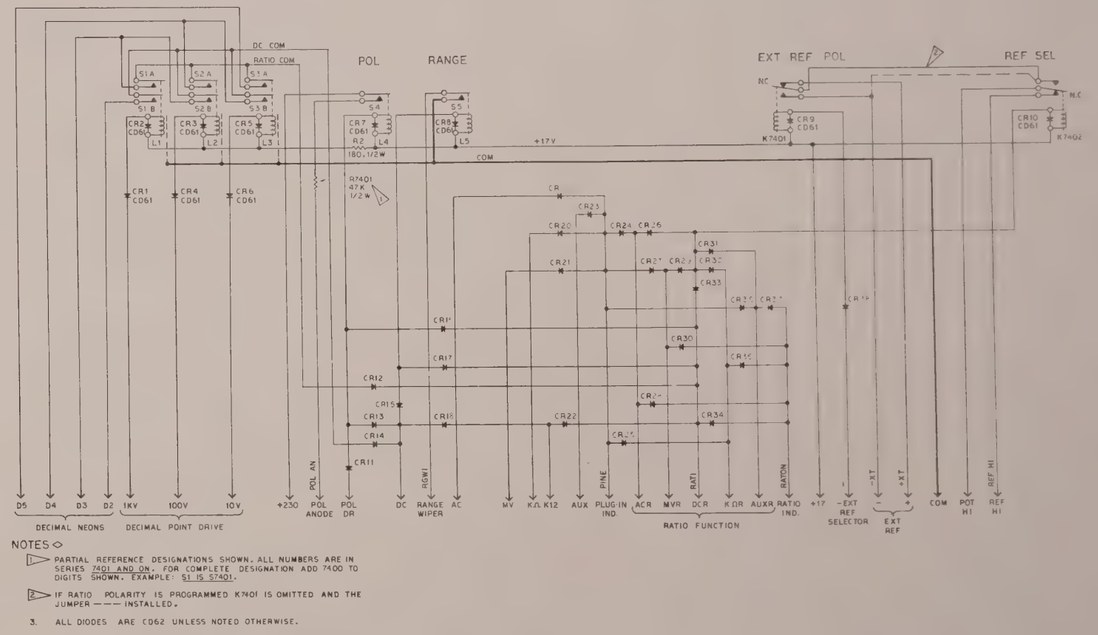


Figure 6-16. Function Ratio.



Schematic 18. Function Ratio.

FUNCTION INDICATOR

ASSEMBLY 90-6036

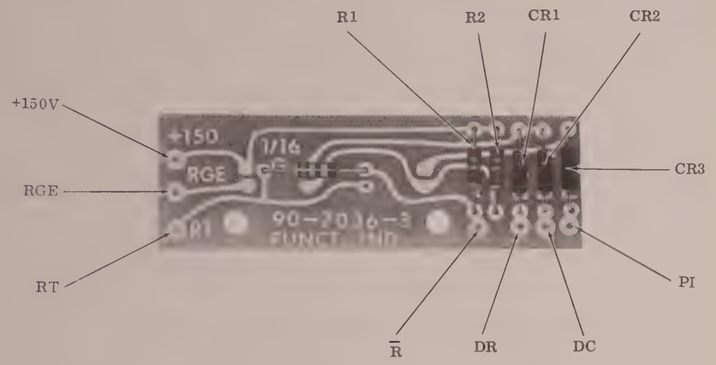
PARTS LIST

ASSEMBLY: Function Indicator CIMRON PART NO. 90-6036

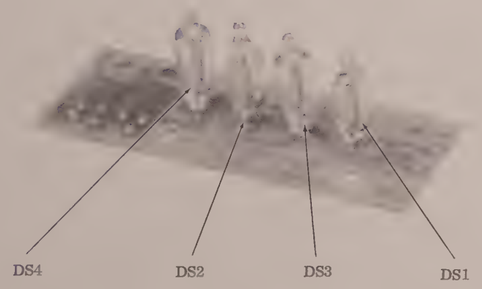
SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
RESISTOR						
R3601, R3602	47KΩ	COMP	1/4W 5%	01121	CB-4735	7-41263
R3603	470KΩ	COMP	1/4W 5%	01121	CB-4745	7-41275
SEMICONDUCTOR						
CR3601 - CR3603		**CD-62 DIODE		15318		7-95507
MISCELLANEOUS						
DS3601 - DS3604		LAMP, GLOW, NE-2H			NE-2H	5-46501
		MY NEG FUNCTION LEGEND		15318		80-0400-1
		BLOCK READOUT FUNCTION		15318		80-3009-1
		ETCHED BOARD, FUNCTION INDICATOR		15318		90-7036-3
		ETCHED BOARD, INSULATOR		15318		90-7037-1

NOTE

**CD-62, I_f = 1V greater than 100 ma, I_r = 300V less than 6 ua, SILICON

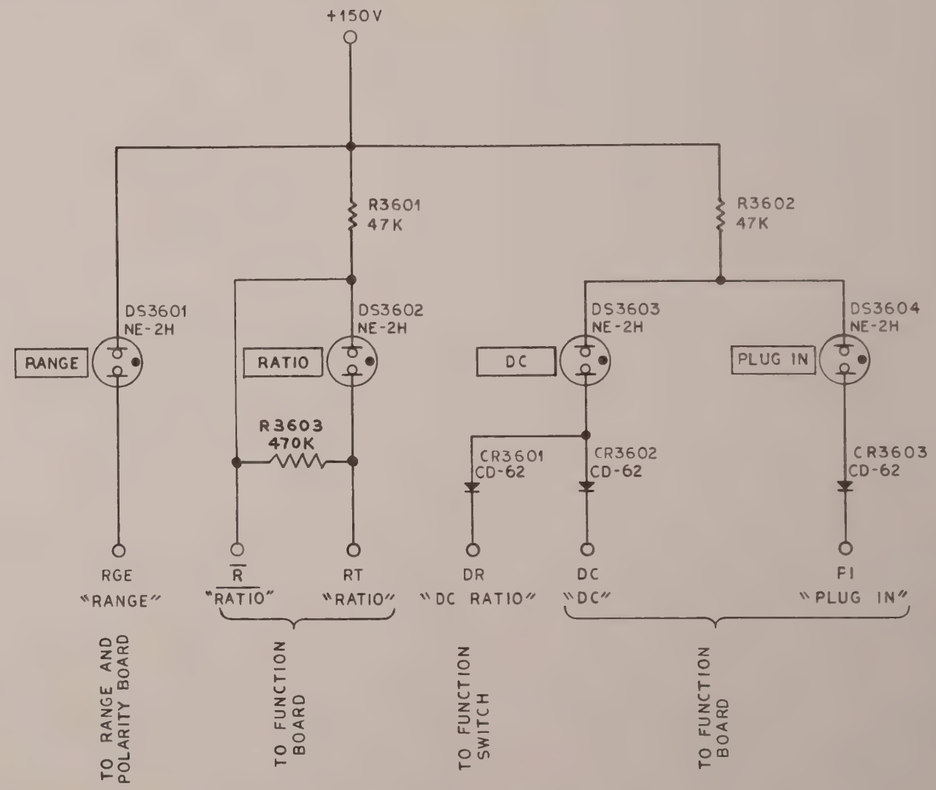


REAR VIEW



FRONT VIEW

Figure 6-17. Function Indicator.



NOTES ◇

1. UNLESS OTHERWISE NOTED RESISTORS ARE 1/4W, ±5% TOLERANCE.

Schematic #19. Function Indicator.

RANGE DETECTOR

ASSEMBLY 90-6088

PARTS LIST

ASSEMBLY: Range Detector CIMRON PART NO. 90-6088

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
CAPACITOR						
C8801	100uf	ELECT	15V	14655	NLW 100-15	1-57247
C8802	2.2uf	TANT	20V 10%	56289	150D225X9020A2	1-57108
C8803	.22uf	MET PAP	50V 10%	12406	VX5A224K	1-57319
RESISTOR						
R8801	2.2KΩ	COMP	1/4W 5%	01121	CB-2225	7-41247
R8802	33KΩ	COMP	1/4W 5%	01121	CB-3335	7-41261
R8803	2.2KΩ	COMP	1/4W 5%	01121	CB-2225	7-41247
R8804	33KΩ	COMP	1/4W 5%	01121	CB-3335	7-41261
R8805	2.2KΩ	COMP	1/4W 5%	01121	CB-2225	7-41247
R8806	33KΩ	COMP	1/4W 5%	01121	CB-3335	7-41261
R8807	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R8808	2.2KΩ	COMP	1/4W 5%	01121	CB-2225	7-41247
R8809	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R8810	2.2KΩ	COMP	1/4W 5%	01121	CB-2225	7-41247
R8811	33KΩ	COMP	1/4W 5%	01121	CB-3335	7-41261
R8812	18KΩ	COMP	1/4W 5%	01121	CB-1835	7-41258
R8813	1.8KΩ	COMP	1/4W 5%	01121	CB-1825	7-41246
R8814	27KΩ	COMP	1/4W 5%	01121	CB-2735	7-41260
R8815	470Ω	COMP	1/4W 5%	01121	CB-4715	7-41239
R8816	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R8817	15KΩ	COMP	1/4W 5%	01121	CB-1535	7-41257
R8818 - R8820	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R8821	5.6KΩ	COMP	1/4W 5%	01121	CB-5625	7-41252
R8822	33KΩ	COMP	1/4W 5%	01121	CB-3335	7-41261
R8823	15KΩ	COMP	1/4W 5%	01121	CB-1535	7-41257
R8824	8.2KΩ	COMP	1/4W 5%	01121	CB-8225	7-41254
R8825	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R8826	390KΩ	COMP	1/4W 5%	01121	CB-3945	7-41274
R8827	1MΩ	COMP	1/4W 5%	01121	CB-1055	7-41279
SEMICONDUCTOR						
CR8801 - CR8806		**CD-62 DIODE		15318		7-95507
CR8807		**CD-61 DIODE		15318		7-95511
CR8808		ZENER 1N710A		JEDEC	1N710A	7-95627
CR8809		**CD-61 DIODE		15318		7-95511
CR8810		**CD-62 DIODE		15318		7-95507

PARTS LIST

ASSEMBLY: Range Detector CIMRON PART NO. 90-6088

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
SEMICONDUCTOR (Cont'd)						
CR8811 - CR8813		**CD-61 DIODE		15318		7-95511
CR8814		ZENER 1N718A		JEDEC	1N718A	7-95633
CR8815		**CD-61 DIODE		15318		7-95511
CR8816		**CD-62 DIODE		15318		7-95507
TRANSISTOR						
Q8801 - Q8805		2N404A		JEDEC	2N404A	9-04609
Q8806		**CT-26		15318		9-04710
Q8807		**CT-23		15318		9-04706
Q8808		**CT-20		15318		9-04701
Q8809, Q8810		**CT-26		15318		9-04710
REED						
S8801, S8802		RELAY		95348	MR306-8	7-38216
COIL						
L8801, L8802		REED SWITCH ACTUATOR		15318		50-0501-1
MISCELLANEOUS						
		ETCHED BOARD, RANGE DETECTOR		15318		90-7088-1

NOTE

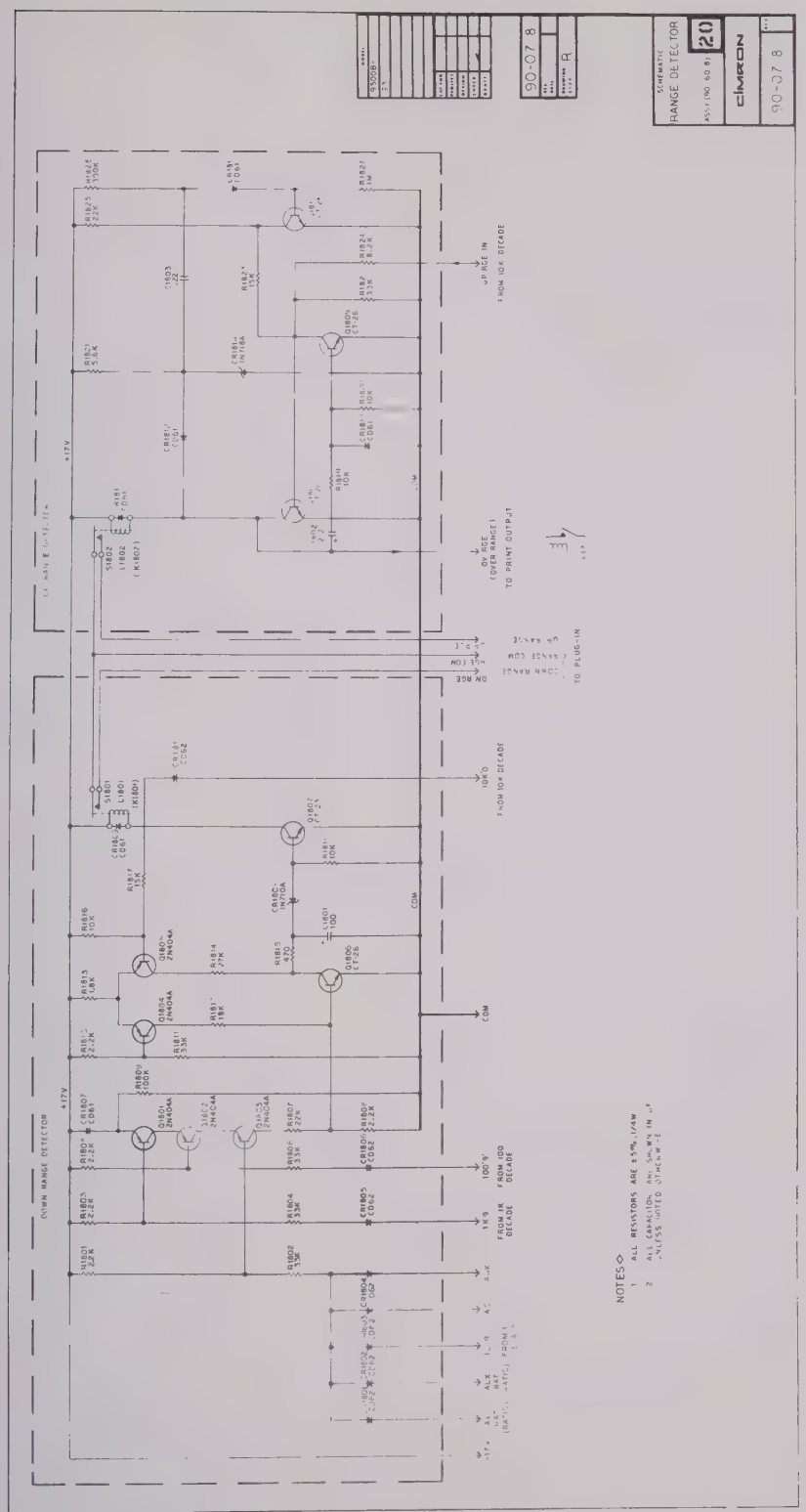
**CD-61, I_f = 1V greater than 100 ma, I_r = 75V less than 1 ua, SILICON

**CD-62, I_f = 1V greater than 100 ma, I_r = 300V less than 6 ua, SILICON

**CT-20 = 2N697

**CT-23 = 2N697

**CT-26 = 2N2222



Schematic 20. Range Detector

POWER SUPPLY

ASSEMBLY 90-6071

PARTS LIST

ASSEMBLY: Power Supply CIMRON PART NO. 90-6071

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		CIMRON PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
CAPACITOR						
C1701 - C1706	100uf	ELECT	25V	14655	NLW 100-25	1-57253
C1707	200uf	ELECT	15V	14655	NLW 200-15	1-57248
C1708	5nf	DISC	50V	71590	CK-502	1-57512
C1709	100uf	ELECT	25V	14655	NLW 100-25	1-57253
RESISTOR						
R1701	1KΩ	WW	3W 5%	56289	242E-1025	7-47140
R1702 - R1704	1KΩ	COMP	1/4W 5%	01121	CB-1025	7-41243
R1705	22Ω	COMP	1/2W 5%	01121	EB-2205	7-41023
R1706	1KΩ	COMP	1/4W 5%	01121	CB-1025	7-41243
R1707, R1708	1Ω	WW	3W 1%	04387	RS-2B	7-47208
R1709	2.2KΩ	COMP	1/4W 5%	01121	CB-2225	7-41247
SEMICONDUCTOR						
CR1709		1N712A Z - DIODE		JEDEC	1N712A	7-95632
CR1710 - CR1712		**CD-61 DIODE		15318		7-95511
CR1713		1N712A Z - DIODE		JEDEC	1N712A	7-95632
TRANSISTOR						
Q1701		2N2538		JEDEC	2N2538	9-04711
Q1702		**CT-26		15318		9-04710
MISCELLANEOUS						
TP7		TEST JACK, VIOLET		82042	TJ-51-10	5-19010
TP8		TEST JACK, GRAY		82042	TJ-51-9	5-19009
TP9		TEST JACK, WHITE		82042	TJ-51-1	5-19001
TP10		TEST JACK, BLACK		82042	TJ-51-3	5-19003
TP11		TEST JACK, BROWN		82042	TJ-51-4	5-19004
		ETCHED BOARD, POWER SUPPLY		15318		90-7017-3
		HEAT SINK				4-65000

NOTE

**CT-61, I_f = 1V greater than 100 ma, I_r = 75V less than 1 ua, SILICON

**CT-26 = 2N2222

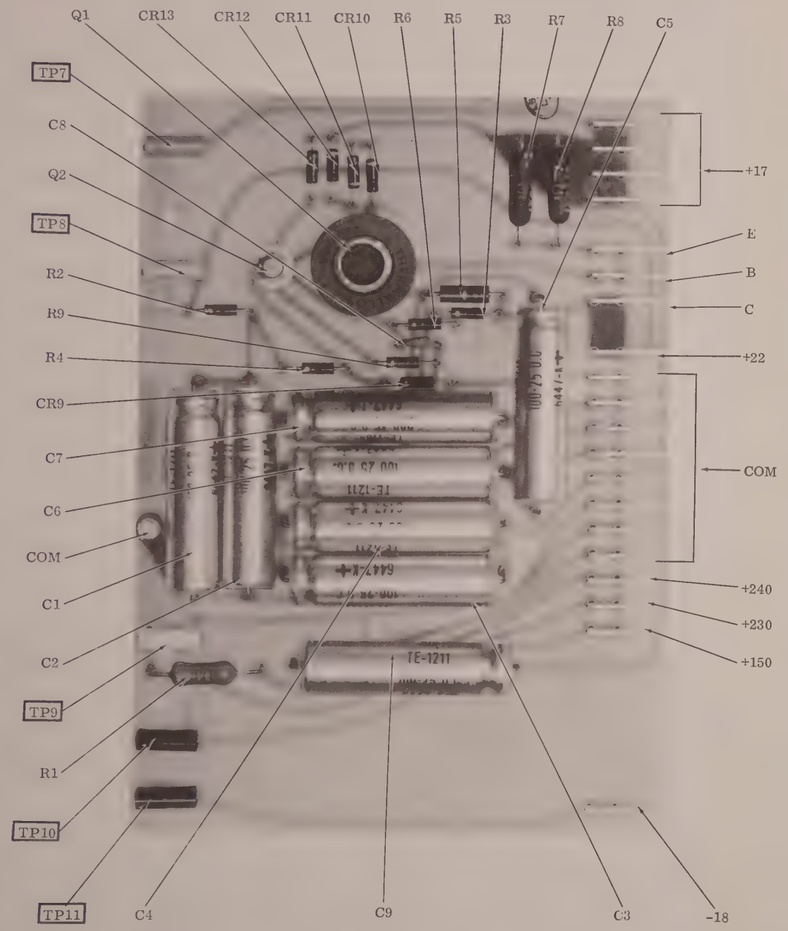
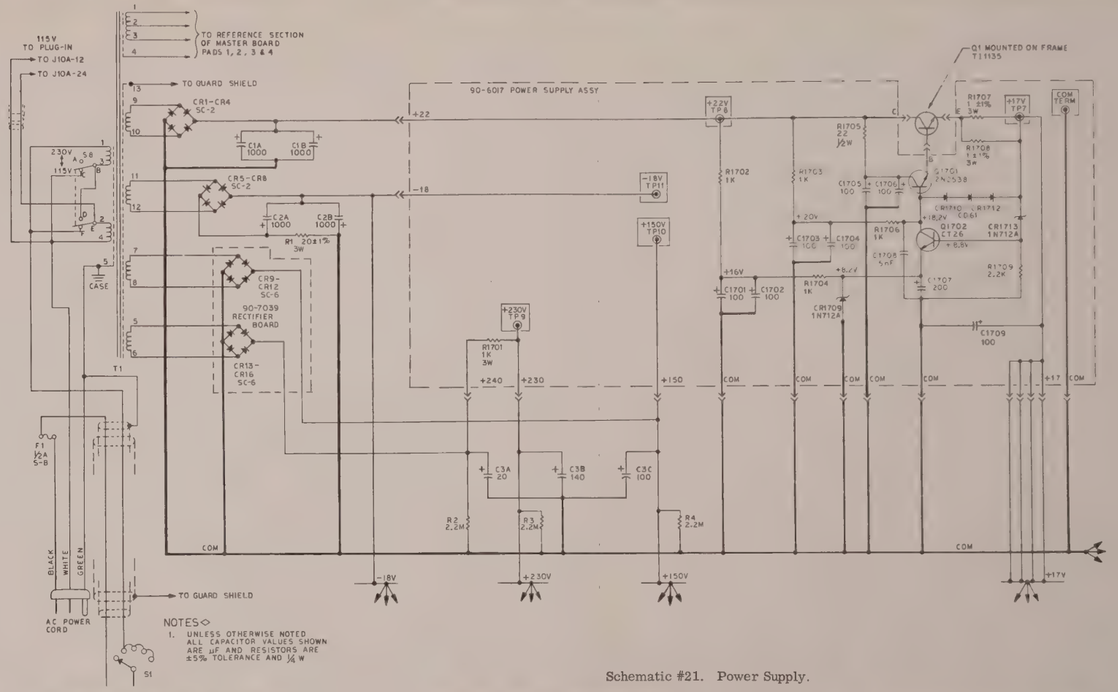
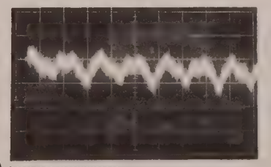


Figure 6-19. Power Supply.

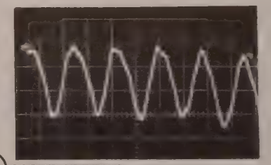


Schematic #21. Power Supply.

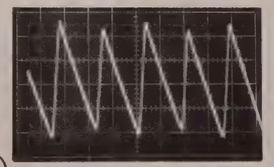


TP (7) SCOPE SETTING
VERTICAL SENSITIVITY 0.1mV/cm
HORIZONTAL SWEEP 5ms/cm

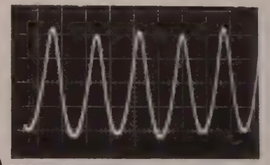
TP (8) SCOPE SETTING
VERTICAL SENSITIVITY 0.2V/cm
HORIZONTAL SWEEP 5ms/cm



TP (9) SCOPE SETTING
VERTICAL SENSITIVITY 10mV/cm
HORIZONTAL SWEEP 5ms/cm



TP (10) SCOPE SETTING
VERTICAL SENSITIVITY 50mV/cm
HORIZONTAL SWEEP 5ms/cm



TP (11) SCOPE SETTING
VERTICAL SENSITIVITY 2mV/cm
HORIZONTAL SWEEP 5ms/cm

PRINT CONTROL

ASSEMBLY 90-6015

PARTS LIST

ASSEMBLY: Print Control CIMRON PART NO. 90-6015

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
CAPACITOR						
C1501	10uf	MET PAP	100V 10%	12406	VX1A106K	1-57341
C1503, C1504	1.8nf	DISC	1000V 10%	71590	DD-182	1-57503
C1505	5nf	DISC	50V	71590	CK-502	1-57512
C1506	1uf	MET PAP	50V 10%	12406	VX5A105K	1-57317
C1507	0.01uf	DISC	50V	71590	CK-103	1-57513
C1508	4.7uf	TANT	35V 20%	01295	SCM475BP035D4	1-57106
C1509	1.8nf	DISC	1000V 10%	71590	DD-183	1-57503
C1510	1uf	MET PAP	50V 10%	12406	VX5A105K	1-57317
C1511	5nf	DISC	50V	71590	CK-502	1-57512
C1512	1.8nf	DISC	1000V 10%	71590	DD-182	1-57503
C1513	22uf	TANT	35V 20%	01295	SCM226GP035D4	1-57102
C1514	4.7uf	TANT	35V 20%	01295	SCM475TP035D4	1-57106
C1515	10nf	DISC	50V	71590	CK-103	1-57513
C1516	1uf	MET PAP	50V 10%	12406	VX5A105K	1-57317
C1517	25uf	ELECT	25V	14655	NLW 25-25	1-57223
C1518	22nf	DIP PAP	400V 10%	04062	4DP-2-223	1-57415
C1519 - C1521	5nf	DISC	50V	71590	CK-502	1-57512
RESISTOR						
R1501	2MΩ	VAR TRIM COMP	1/8W	11237	220S205B	7-48807
R1502	470KΩ	COMP	1/4W 5%	01121	CB-4745	7-41275
R1503	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R1504	2.2KΩ	COMP	1/4W 5%	01121	CB-2225	7-41247
R1505	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R1506, R1507	6.8KΩ	COMP	1/4W 5%	01121	CB-6825	7-41253
R1508	27KΩ	COMP	1/4W 5%	01121	CB-2735	7-41260
R1509	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R1510	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R1511	47KΩ	COMP	1/4W 5%	01121	CB-4735	7-41263
R1512	6.8KΩ	COMP	1/4W 5%	01121	CB-6825	7-41253
R1513	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R1514	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R1515	1KΩ	COMP	1/4W 5%	01121	CB-1025	7-41243
R1516	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R1517, R1518	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R1519	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R1520	1MΩ	COMP	1/4W 5%	01121	CB-1055	7-41279

PARTS LIST

ASSEMBLY: Print Control (Cont'd) CIMRON PART NO. 90-6015

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
RESISTOR (Cont'd)						
R1521	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R1522	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R1523	500KΩ	VAR TRIM COMP	1/8W	11237	SERIES 220-2	7-48810
R1524	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R1525	1MΩ	COMP	1/4W 5%	01121	CB-1055	7-41279
R1526	68KΩ	COMP	1/4W 5%	01121	CB-6835	7-41265
R1527	33KΩ	COMP	1/4W 5%	01121	CB-3335	7-41061
R1528	6.8KΩ	COMP	1/4W 5%	01121	CB-6825	7-41253
R1529	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R1530	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R1531	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R1532	15KΩ	COMP	1/4W 5%	01121	CB-1535	7-41257
R1533	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R1534	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R1535	6.8KΩ	COMP	1/4W 5%	01121	CB-6825	7-41253
R1536	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R1537	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R1538	6.8KΩ	COMP	1/4W 5%	01121	CB-6825	7-41253
R1539	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R1540	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R1541, R1542	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R1543	470KΩ	COMP	1/4W 5%	01121	CB-4745	7-41275
R1544	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R1545	6.8KΩ	COMP	1/4W 5%	01121	CB-6825	7-41253
R1546	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R1547	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R1548	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R1549	100KΩ	VAR TRIM COMP	1/8W	11237	220S104B	7-48809
R1550	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R1551	6.8KΩ	COMP	1/4W 5%	01121	CB-6825	7-41253
R1552	10KΩ	COMP	1/4W 5%	01121	CB-1035	7-41255
R1553	100KΩ	COMP	1/4W 5%	01121	CB-1045	7-41267
R1554	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259
R1555	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R1556	56KΩ	COMP	1/4W 5%	01121	CB-5635	7-41264
R1557	22KΩ	COMP	1/4W 5%	01121	CB-2235	7-41259

PARTS LIST

ASSEMBLY: Print Control (Cont'd) CIMRON PART NO. 90-6015

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
RESISTOR (Cont'd)						
R1558	680Ω	COMP	1/4W 5%	01121	CB-6815	7-41241
R1559	4.7KΩ	COMP	1/4W 5%	01121	CB-4725	7-41251
R1560 - R1562	100Ω	COMP	1/4W 5%	01121	CB-1015	7-41231
SEMICONDUCTOR						
CR1501 - CR1515		**CD-61 DIODE		15318		7-95511
CR1516		1N714A Z - DIODE		JEDEC	1N714A	7-95630
CR1517 - CR1521, CR1423 - CR1532		**CD-61 DIODE		15318		7-95511
TRANSISTOR						
Q1501		**CT-22		15318		9-04705
Q1502, Q1503		**CT-26		15318		9-04710
Q1504		2N404A		JEDEC	2N404A	9-04609
Q1505 - Q1507		**CT-26		15318		9-04710
Q1508		2N404A		JEDEC	2N404A	9-04609
Q1509		**CT-23		15318		9-04706
Q1510		2N404A		JEDEC	2N404A	9-04609
Q1511		**CT-23		15318		9-04706
Q1512		2N404A		JEDEC	2N404A	9-04609
Q1513		**CT-23		15318		9-04706
Q1514		2N404A		JEDEC	2N404A	9-04609
Q1515		**CT-26		15318		9-04710
Q1516		**CT-23		15318		9-04706
MISCELLANEOUS						
DS1501		LAMP, GLOW			NE-2H	5-46501
		ETCHED BOARD, PRINT CONTROL		15318		90-7015-5

NOTE

**CD-61, I_f = 1V greater than 100 ma, I_r = 75V less than 1 ua, SILICON

**CT-22 = 2N3114

**CT-23 = 2N697

**CT-26 = 2N2222

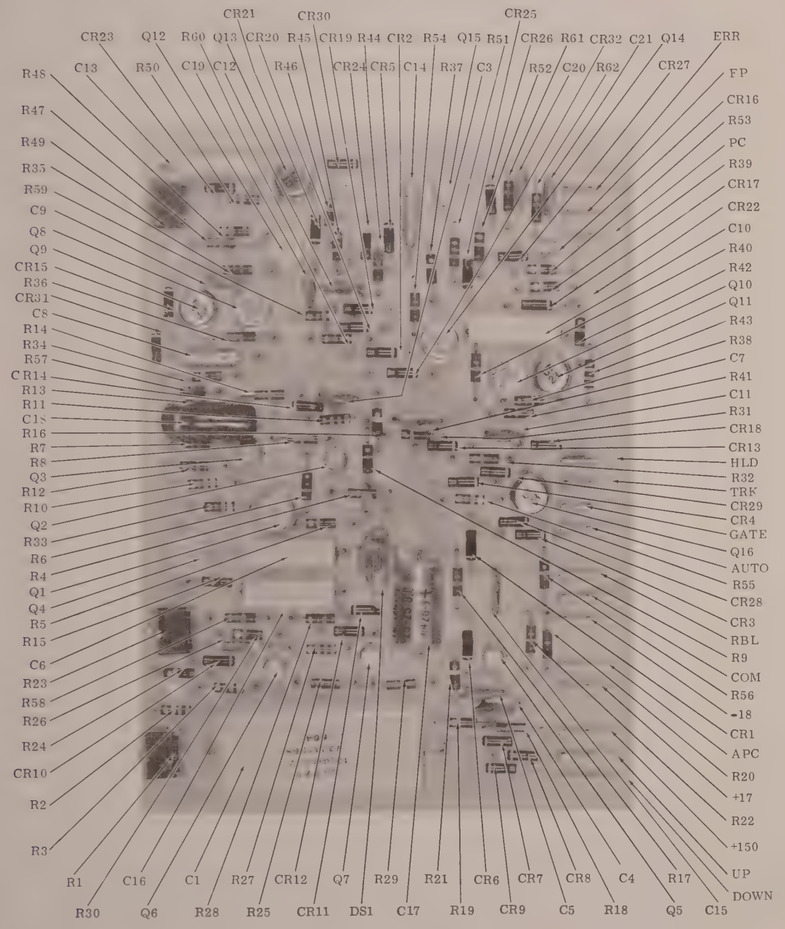
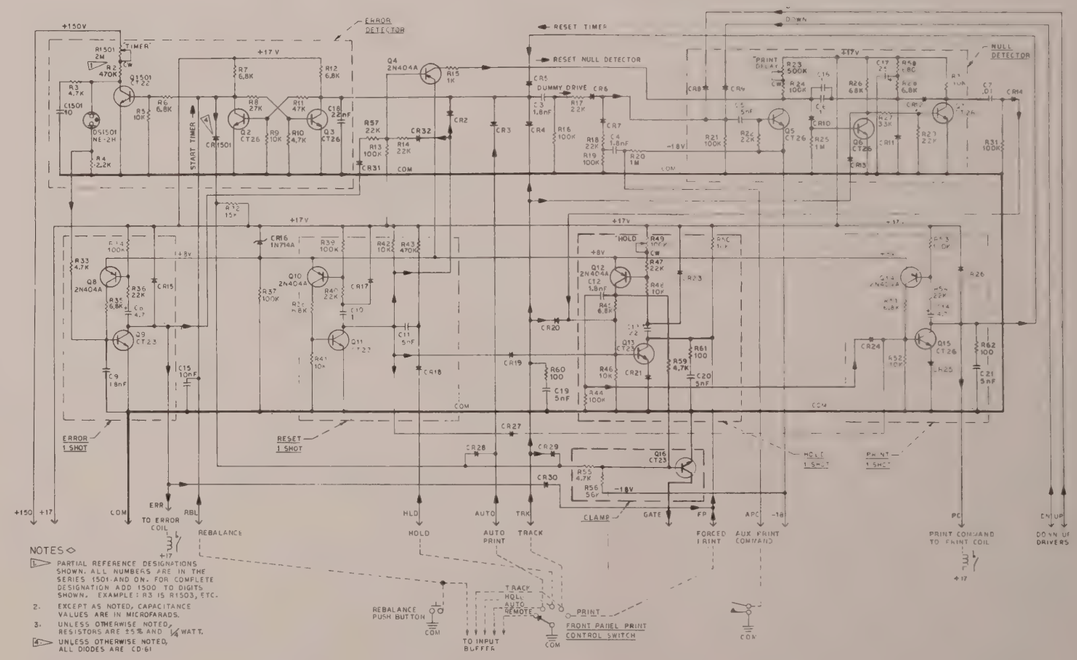


Figure 6-20. Print Control.



Schematic #22. Print Control.

PRINT OUTPUT A

ASSEMBLY 90-6040

PRINT OUTPUT B

ASSEMBLY 90-6041

PRINT OUTPUT C

ASSEMBLY 90-6042

PARTS LIST

ASSEMBLY: Print Output "A" CIMRON PART NO. 90-6040

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
SEMICONDUCTOR						
CR4001 - CR4023		**CD-61 DIODE		15318		7-95511
CR4024 - CR4046		**CD-62 DIODE		15318		7-95507
REED						
S4001 - S4023		RELAY		95348	MR-306-8	7-38216
COIL						
L4001 - L4023		REED SWITCH ACTUATOR		15318		90-0504-1
MISCELLANEOUS						
		ETCHED BOARD, PRINT OUTPUT "A"		15318		90-7040-1

ASSEMBLY: Print Output "B" CIMRON PART NO. 90-6041

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
SEMICONDUCTOR						
CR4101 - CR4123		**CD-61 DIODE		15318		7-95511
CR4124 - CR4146		**CD-62 DIODE		15318		7-95507
REED						
S4101 - S4123		RELAY		95348	MR-306-8	7-38216
COIL						
L4101 - L4123		REED SWITCH ACTUATOR		15318		90-0504-1
MISCELLANEOUS						
		ETCHED BOARD, PRINT OUTPUT "B"		15318		90-7041-1

ASSEMBLY: Print Output "C" CIMRON PART NO. 90-6042

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
SEMICONDUCTOR						
CR4201 - CR4224		**CD-61 DIODE		15318		7-95511
CR4225 - CR4248		**CD-62 DIODE		15318		7-95507
REED						
S4201 - S4224		RELAY		95348	MR-306-8	7-38216
COIL						
L4201 - L4224		REED SWITCH ACTUATOR		15318		90-0504-1
MISCELLANEOUS						
		ETCHED BOARD, PRINT OUTPUT "C"		15318		90-7042-1

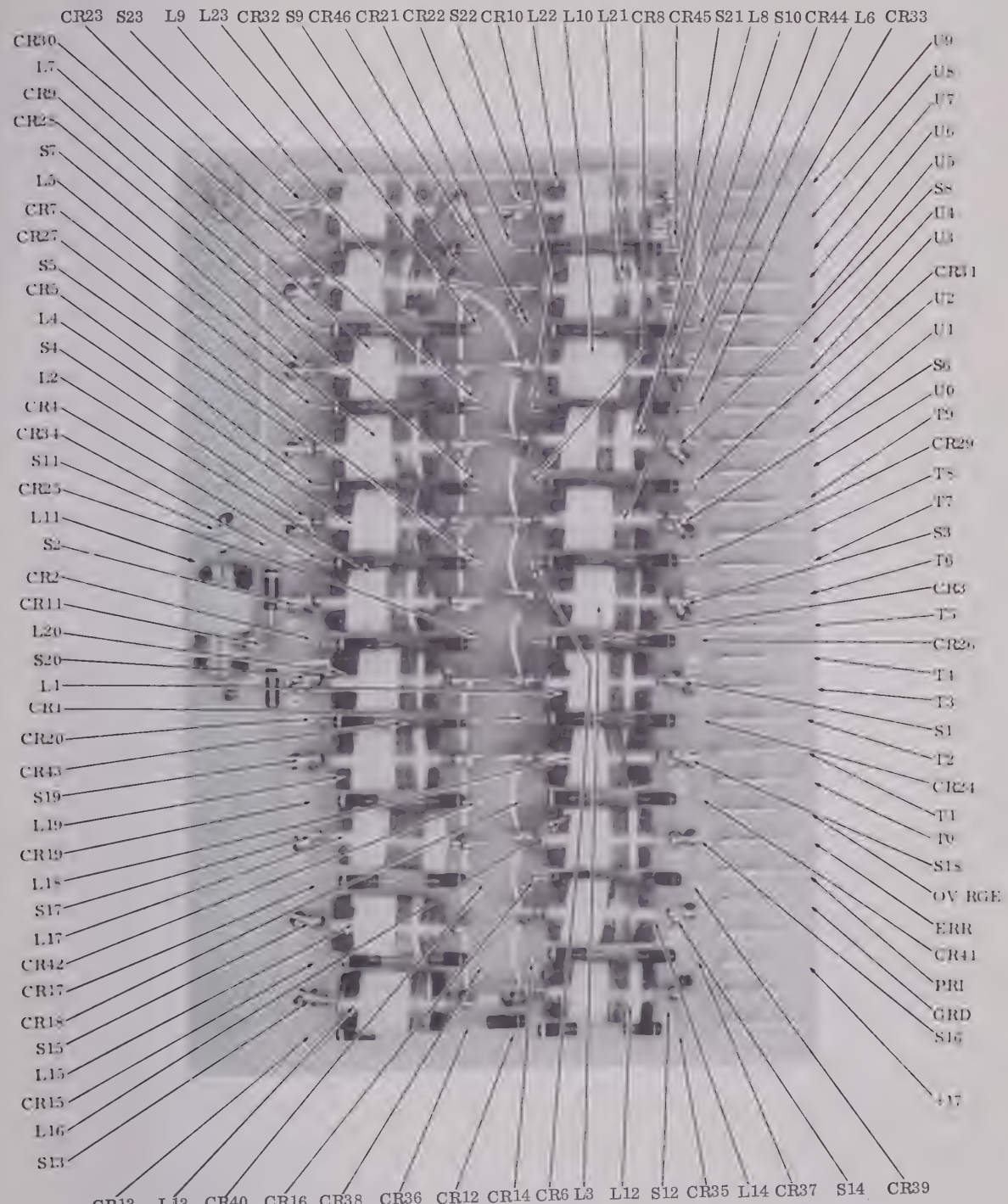


Figure 6-21. Print Output A.

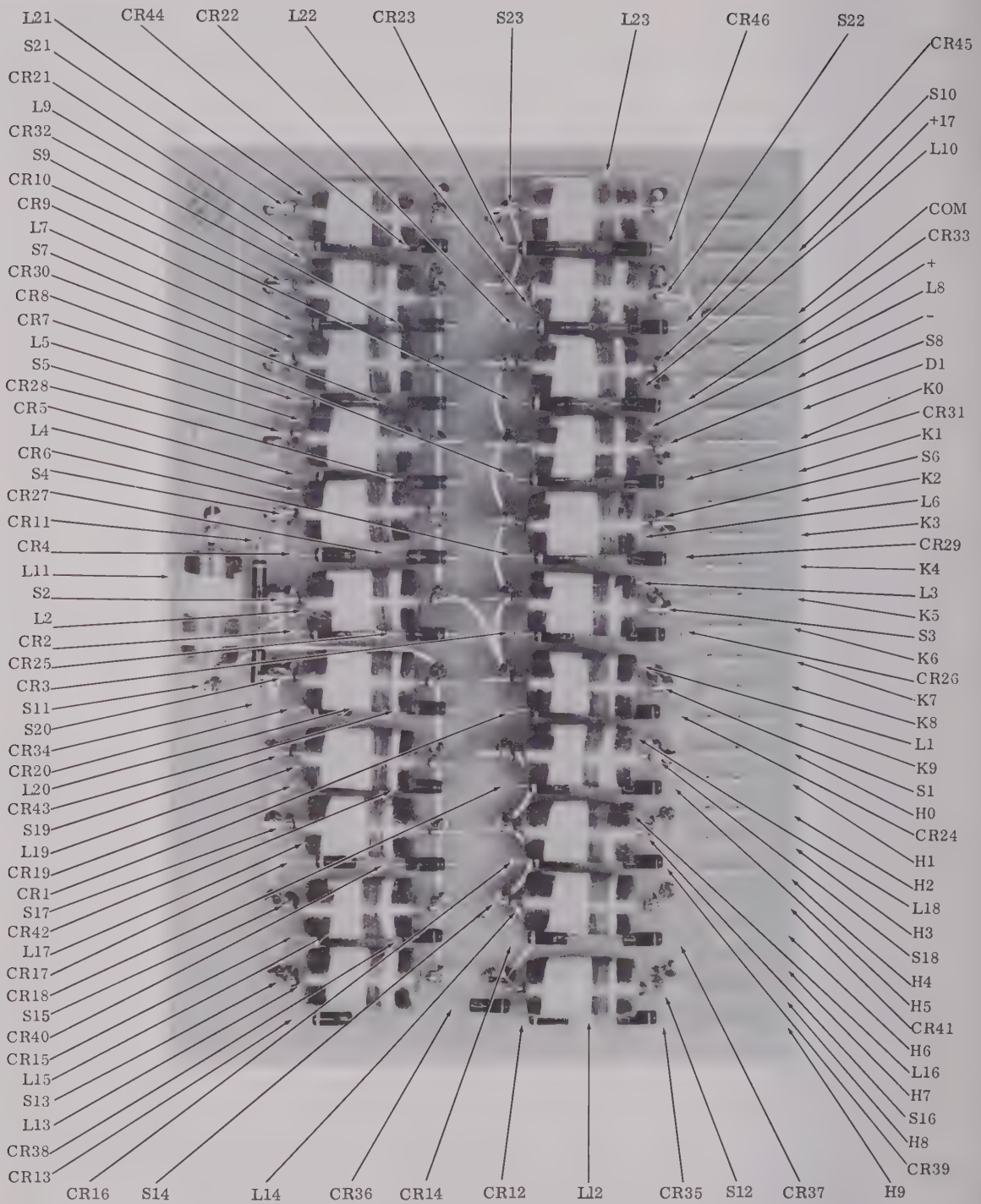


Figure 6-22. Print Output B.

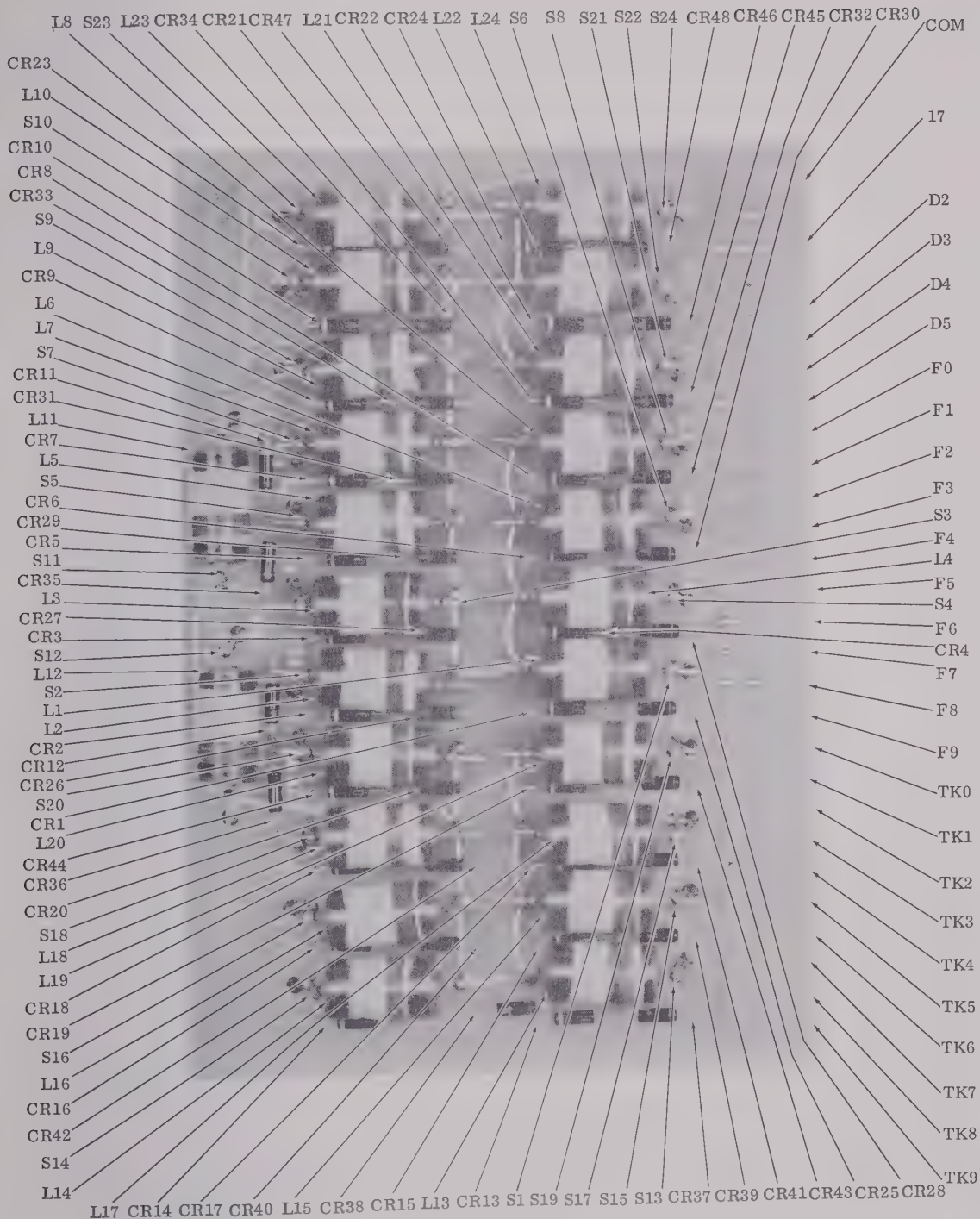
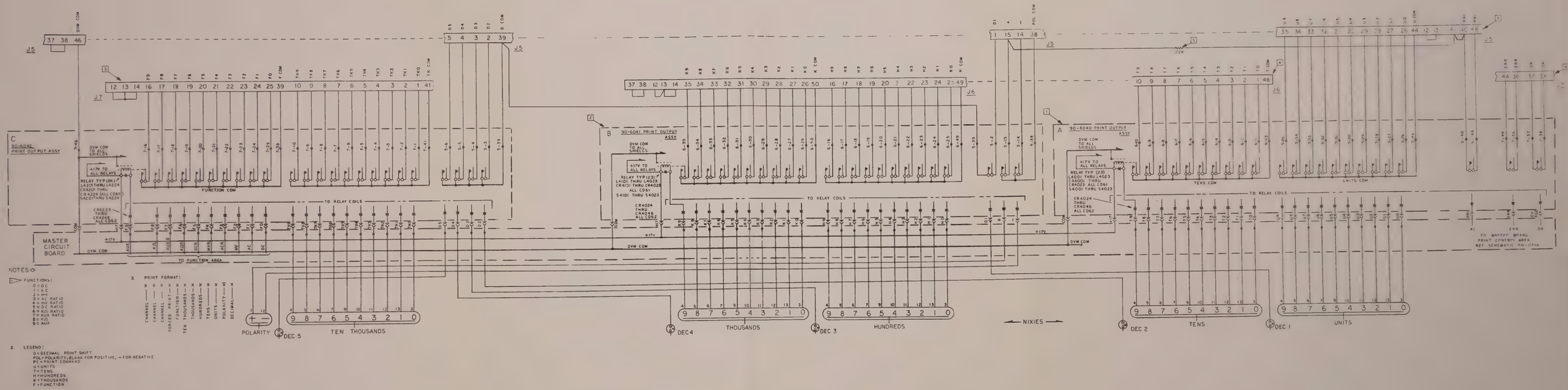


Figure 6-23. Print Output C.



NOTES:

1. FUNCTIONS:
   0 = DC
   1 = AC
   2 = mV
   3 = AC RATIO
   4 = mV RATIO
   5 = DC RATIO
   6 = KΩ RATIO
   7 = AUX RATIO
   8 = KΩ
   9 = AUX

2. LEGEND:
   D = DECIMAL POINT SHIFT
   POL = POLARITY, BLANK FOR POSITIVE, — FOR NEGATIVE
   PC = PRINT COMMAND
   U = UNITS
   T = TENS
   H = HUNDREDS
   K = THOUSANDS
   F = FUNCTION

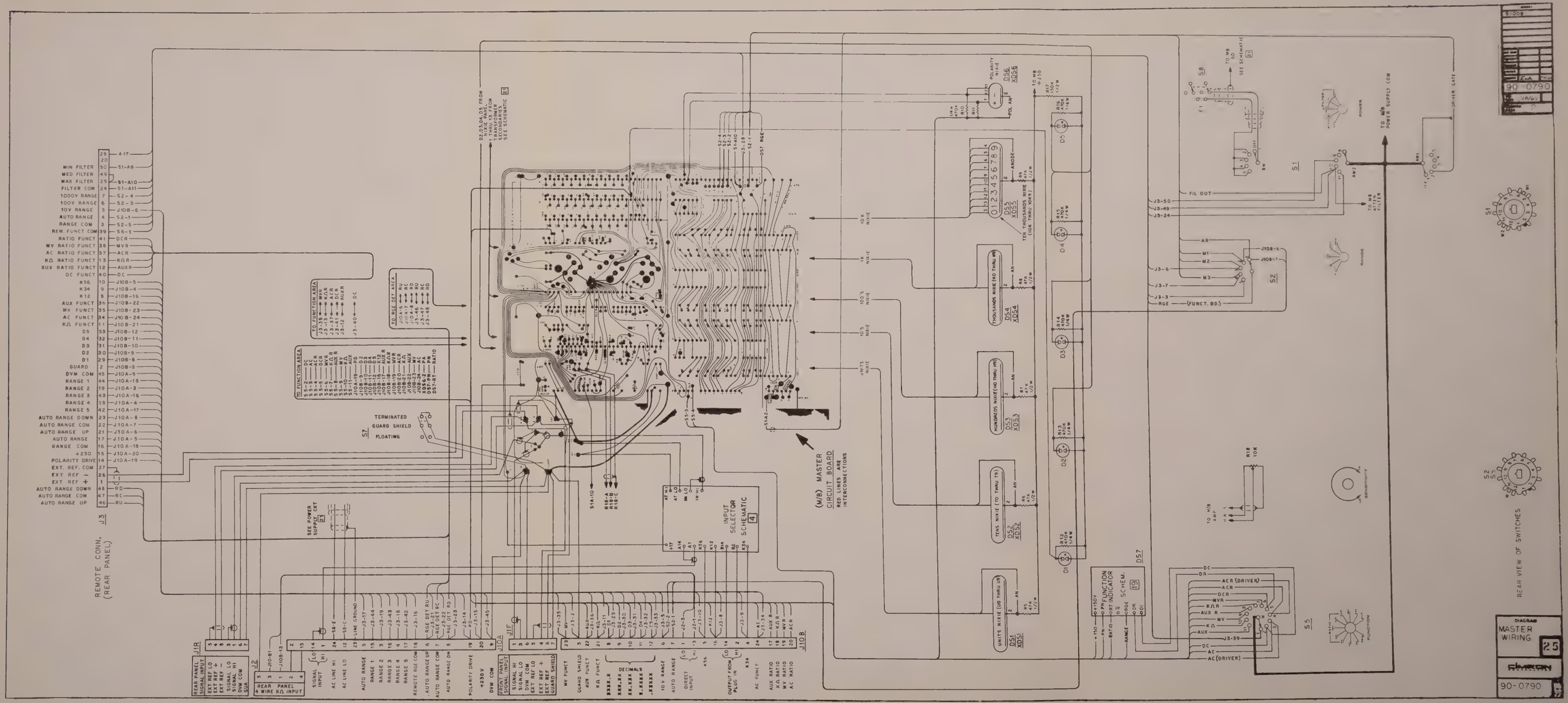
3. PRINT FORMAT:
   X X X X X X X X X X X X
   CHANNEL — — — — — — — — — — — —
   CHANNEL — — — — — — — — — — — —
   FORCED PRINT — — — — — — — — — — — —
   FUNCTION — — — — — — — — — — — —
   TEN THOUSANDS — — — — — — — — — — — —
   THOUSANDS — — — — — — — — — — — —
   HUNDREDS — — — — — — — — — — — —
   TENS — — — — — — — — — — — —
   UNITS — — — — — — — — — — — —
   POLARITY — — — — — — — — — — — —
   DECIMAL — — — — — — — — — — — —

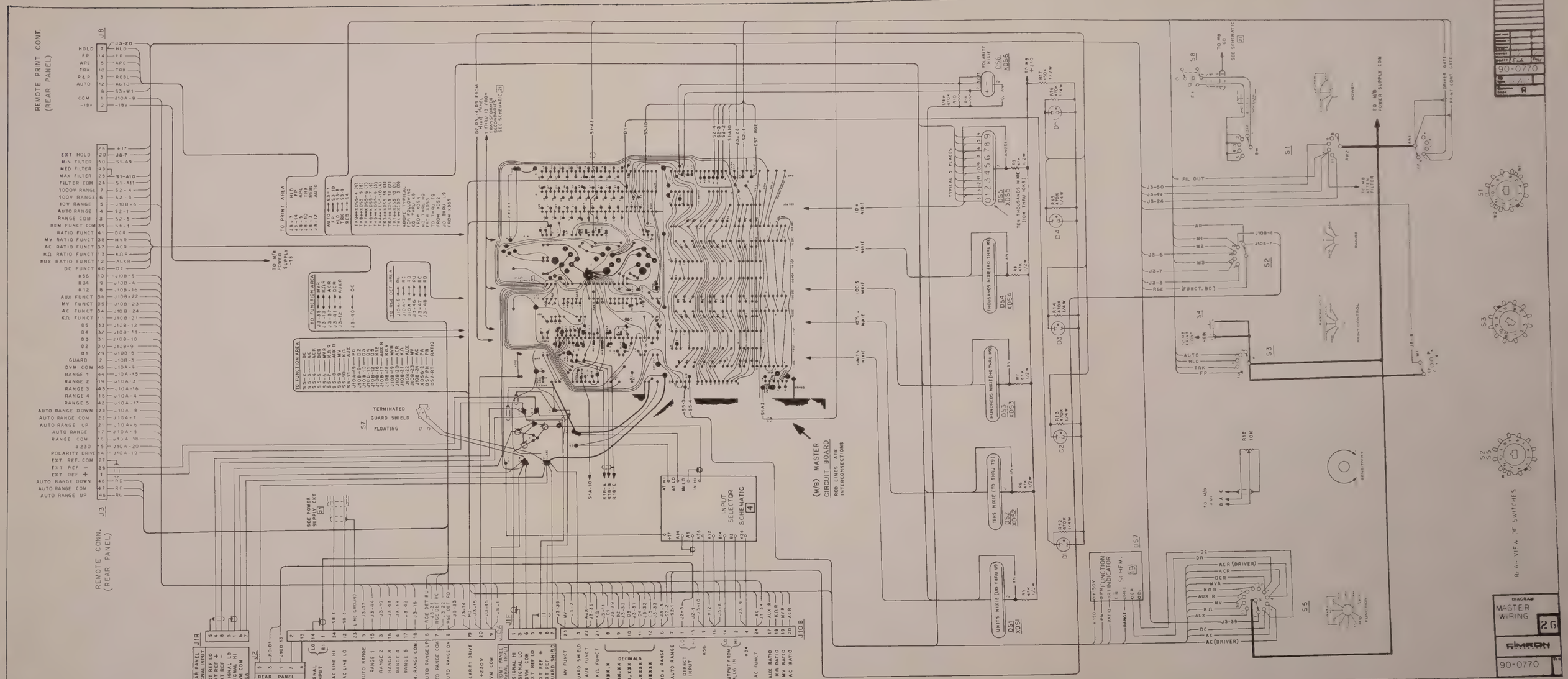
Schematic #23, Print Output.

PARTS LIST

MASTER ASSEMBLY

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	CIMRON PART NO.
MISCELLANEOUS (Cont'd)						
		BRACKET, RACK MOUNTING		15318		90-3022-3
		BEZELS		15318		90-3023-1
		COVER CASE		15318		11-3064-1
		ANGLE, BEZEL MOUNTING		15318		90-3025-1
		COVER, SIDE PANEL		15318		11-3071-1
		COVER, MOUNTING BRACKET		15318		11-3047-1
		GUARD SHIELD, BOTTOM		15318		90-3028-1
		CORD, AC POWER		15318		2-70000
		FUSE HOLDER		75915	342004	4-12000
		GROMMET - POWER CORD STRAIN RELIEF		28520	SR-6P-1	4-35000
		POST, BINDING		83330	136	6-94005


REMOTE CONN. (REAR PANEL) J3
MIN FILTER
MED FILTER
MAX FILTER
FILTER COM
1000V RANGE
100V RANGE
10V RANGE
AUTO RANGE
RANGE COM
REM. FUNCT COM
RATIO FUNCT
MV RATIO FUNCT
AC RATIO FUNCT
KΩ RATIO FUNCT
AUX RATIO FUNCT
DC FUNCT
K56
K34
K12
AUX FUNCT
MV FUNCT
AC FUNCT
KΩ FUNCT
D5
D4
D3
D2
D1
GUARD
DVM COM
RANGE 1
RANGE 2
RANGE 3
RANGE 4
RANGE 5
AUTO RANGE DOWN
AUTO RANGE COM
AUTO RANGE UP
AUTO RANGE
RANGE COM
+230
POLARITY DRIVE
EXT. REF. COM
EXT REF −
EXT REF +
AUTO RANGE DOWN
AUTO RANGE COM
AUTO RANGE UP
REAR PANEL SIGNAL INPUT J1R
EXT REF LO
EXT REF +
EXT REF −
SIGNAL LO
SIGNAL HI
DVM COM
GUARD
J2
REAR PANEL 4 WIRE KΩ INPUT
SIGNAL INPUT
AC LINE HI
AC LINE LO
AUTO RANGE
RANGE 1
RANGE 2
RANGE 3
RANGE 4
RANGE 5
REMOTE RGE COM
AUTO RANGE UP
AUTO RANGE COM
AUTO RANGE DN
POLARITY DRIVE
+230V
DVM COM
FRONT PANEL SIGNAL INPUT J1F
SIGNAL HI
SIGNAL LO
DVM COM
EXT REF LO
EXT REF +
EXT REF −
GUARD SHIELD
MV FUNCT
GUARD SHIELD
AUX FUNCT
KΩ FUNCT
DECIMALS
10V RANGE
AUTO RANGE
DIRECT INPUT
OUTPUT FROM PLUG IN
AC FUNCT
AUX RATIO
KΩ RATIO
MV RATIO
AC RATIO
J10B
TO FUNCTION AREA
TO RGE DET AREA
TERMINATED
GUARD SHIELD
FLOATING
S7
SEE POWER SUPPLY CKT 23
INPUT SELECTOR SCHEMATIC 4
(W/B) MASTER CIRCUIT BOARD
RED LINES ARE INTERCONNECTIONS
D2,D3,D4,D5 FROM NIXIE PANEL
VIEW FROM TRANSFORMER SECONDARIES SEE SCHEMATIC 21
DS7 RGE
DS6 X056 POLARITY NIXIE
DS5 X055 THOUSANDS NIXIE (10K THRU 90MS)
DS4 X054 THOUSANDS NIXIE (KΩ THRU MΩ)
DS3 X053 HUNDREDS NIXIE (KΩ THRU MΩ)
DS2 X052 TENS NIXIE (1Ω THRU T9)
DS1 X051 UNITS NIXIE (1Ω THRU MΩ)
TENS NIXIE
UNITS NIXIE
R16 470K 1/4W
R15 470K 1/4W
R14 470K 1/4W
R13 470K 1/4W
R12 470K 1/4W
R11 470K 1/4W
R17 470K 1/4W
R18 10K
R10 100K
R9 47K 1/2W
R8 47K 1/2W
R7 47K 1/2W
R6 47K 1/2W
R5 47K 1/2W
D1 D2 D3 D4 D5
TO MB +230
TO MB POWER SUPPLY CON
TO MB ATTEN FILTER
TO MB AMP
SEE SCHEMATIC 21
F1 .25A
S1 POWER
S2 RANGE
S5 FUNCTION
S8
FIL OUT
J3-50
J3-49
J3-24
J3-6
J3-7
J3-3
RGE (FUNCT. BD.)
AR
M1
M2
M3
J10B-6
J10B-7
DRIVER GATE
SENSITIVITY
+15V
+5V
RATIO
RANGE
FUNCTION
INDICATOR
DS7
SCHEM. 19
DC
DR
ACR (DRIVER)
ACR
DCR
MVR
KΩR
AUX R
MV
KΩ
AUX
J3-39
AC
AC (DRIVER)
REAR VIEW OF SWITCHES
DIAGRAM MASTER WIRING 25
FLUKE
90-0790


REMOTE PRINT CONT. (REAR PANEL)
REMOTE CONN. (REAR PANEL)
(M/B) MASTER CIRCUIT BOARD
RED LINES ARE INTERCONNECTIONS
INPUT SELECTOR SCHEMATIC 4
SEE POWER SUPPLY CKT 2
TERMINATED
GUARD SHIELD
FLOATING
TO M/B POWER SUPPLY COM
TO M/B POWER SUPPLY -18
TO PRINT AREA
TO FUNCTION AREA
TO REF DET AREA
TYPICAL 5 PLACES
THOUSANDS NIXIE (NO THRU #9)
HUNDREDS NIXIE (NO THRU #9)
TENS NIXIE (TO THRU 79)
UNITS NIXIE (105 THRU 129)
TEN THOUSANDS NIXIE (105K THRU 109K)
POLARITY NIXIE
FUNCTION INDICATOR
RANGE SWITCH
SENSITIVITY
PRINT CONTROL
REAR PANEL 4 WIRE KΩ INPUT
REAR PANEL SIGNAL INPUT
DIAGRAM MASTER WIRING 26
FLUKE
90-0770

SECTION VII

RECOMMENDED SPARE PARTS

The following is a list of the recommended spare parts required to maintain a specific number of instruments at a satisfactory level of performance for one year in an isolated area.

TABLE XII
Recommended Spare Parts.

ASSEMBLY OR PART NAME	ASSEMBLY OR PART NUMBER	QUANTITY OF PARTS		
		1 Instrument	5 Instruments	10 Instruments
ATTENUATOR ASSEMBLY	90-6076	1	3	5
AMPLIFIER ASSEMBLY	90-6077	1	3	5
DRIVER ASSEMBLY	90-6075	1	3	5
STANDARD DECADE ASSEMBLY	90-6047	1	3	5
UNIT POTENTIOMETER ASSEMBLY	90-6005	1	3	5
10 POTENTIOMETER ASSEMBLY	90-6006	1	3	5
100 POTENTIOMETER ASSEMBLY	90-6007	1	3	5
1000 POTENTIOMETER ASSEMBLY	90-6008	1	3	5
10K POTENTIOMETER ASSEMBLY	90-6058	1	3	5
RANGE AND POLARITY ASSEMBLY	90-6046	1	3	5
FUNCTION RATIO ASSEMBLY	90-6074	1	3	5
PRINT CONTROL ASSEMBLY	90-6015	1	3	5
10K DECADE ASSEMBLY	90-6048	1	3	5
POWER SUPPLY ASSEMBLY	90-6071	1	3	5
RANGE DETECTOR ASSEMBLY	90-6088	1	3	5
REFERENCE ASSEMBLY	90-6049	1	3	5
INDICATOR READOUT, POLARITY	3-41404	1	1	2
INDICATOR READOUT, NUMERAL	3-41405	1	3	5
FUSE	4-08013	5	10	10
COIL, REED SWITCH ACTUATOR	80-0502-1	1	3	5
REED, RELAY	7-38207	5	10	10
INDICATOR, NEON	5-46501	1	3	5

APPENDIX

TABLE OF CONTENTS

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ABBREVIATION	WORD
a	amperes
AC	Alternating Current
car	carbon
cap	capacitor
cm	centimeter
coef	coefficient
com	common
comp	composition
conn	connection, connector
cps	cycles per second
DC	Direct Current
dep	deposited
demod	demodulator, demodulation
det	detector
disc	ceramic disc
DPDT	Double Pole Double Throw
DVM	Digital Volt Meter
elect	electrolytic
encap	encapsulated
f	farads
f-up	fast-up
fxd	fixed
Ge	germanium
gnd	ground
grd	guard
h	henrys
ind	indicator
ins	insulation
JEDEC	Joint Electronic Device Engineering Council
K	Kilo 10^3
m	milli 10^{-3}
max	maximum
met	metallized
mfr	manufacturer
min	minimum
mini	miniature
mtg	mounting
my	mylar
n	nano 10^{-9}
NC	Normally Closed
Ne	Neon
NO	Normally Open
P	Peak, pico 10^{-12}
pap	paper
pol	polarity
poly	polystyrene
PP	Peak to Peak
pos	position
pot	potentiometer
pwr	power
rec	receptacle
rect	rectifier
res	resistor
rot	rotary
rms	root-mean-square
SCS	Silicon Controlled Switch
sect	section
Si	silicon
sil	silver
SPDT	Single Pole Double Throw
spr	spring
SPST	Single Pole Single Throw
tant	tantalum
td	time delay
therm	thermistor
tol	tolerance
trim	trimmer
u	micro 10^{-6}
var	variable
v	volt
w/	with
W	watts
WW	Wire Wound
w/o	without
Z	impedance
*	optimum value selected at factory or note

LIST OF MANUFACTURERS
CODE TO NAME

FEDERAL SUPPLY CODE	MANUFACTURER	ADDRESS
00194	Walsco Electronics Corp.	Los Angeles, California
00348	Microtran Co., Inc.	Valley Stream, New York
00656	Aerovox Corp.	New Bedford, Massachusetts
00853	Sangamo Electric Co.	Pickens, South Carolina
01121	Allen Bradley Co.	Milwaukee, Wisconsin
01281	T. R. W. Semiconductors, Inc.	Lawndale, California
01295	Texas Instruments, Inc.	Dallas, Texas
02111	Spectrol Electronics Corp.	San Gabriel, California
02567	International Electronics Industries, Inc.	Nashville, Tennessee
02572	Inland Electronics Corp.	Aurora, Illinois
02660	Amphenol-Borg Electronics Corp.	Chicago, Illinois
02768	Fastex Division of Illinois Tool Works	Des Plaines, Illinois
03614	Bussmann Mfg.	Los Angeles, California
03797	Eldema Corp.	Compton, California
03877	Transitron Electronic Corp.	Wakefield, Massachusetts
03911	Clairex Corp.	New York, New York
04062	Elmenco Products Co.	New York, New York
04217	Essex Wire Corp.	Los Angeles, California
04264	Circon Components Co.	Goleta, California
04387	Dale Electronics, Inc., Pacific Division	Burbank, California
04852	Mosley Electronics, Inc.	Bridgeton, Missouri
05276	Pomona Electronics Co., Inc.	Pomona, California
05347	Ultronix, Inc.	San Mateo, California
05593	Illumitronic Engineering Co.	Sunnyvale, California
05704	Alac, Inc.	Glendale, California

FEDERAL SUPPLY CODE	MANUFACTURER	ADDRESS
05791	Lyn-Tron, Inc.	North Hollywood, California
06090	Raychem Corp.	Redwood City, California
06743	Clevite Corp.	Cleveland, Ohio
06751	U. S. Semcor Division of Nuclear Corp of America	Phoenix, Arizona
07088	Kelvin Electric Co.	Van Nuys, California
07115	Corning Glass, Electronic Components	Bradford, Pennsylvania
07150	Electro-Mech Components, Inc.	Van Nuys, California
07344	Bircher Co., Inc.	Rochester, New York
07382	Rotor Clip Co.	Bronx, New York
07694	Triad Corp.	Encino, California
07716	International Resistance Co.	Burlington, Iowa
07910	Continental Device Corp.	Hawthorne, California
08065	Accurate Rubber and Plastics Co.	San Diego, California
08538	Chicago Dynamic Industries, Inc.	Chicago, Illinois
08664	Bristol Co.	Waterbury, Connecticut
08795	Rayclad Tubes, Inc.	Redwood City, California
09097	Electronic Enclosures, Inc.	Los Angeles, California
09145	Atohm Electronics	Sun Valley, California
09772	West Coast Lock Washer Co.	Downey, California
09985	Trolex Corp.	Elkhart, Indiana
10003	Grant Pulley and Hardware Co.	Los Angeles, California
11115	Tung-Sol Electric, Inc.	Bloomfield, New Jersey
11237	Chicago Telephone of California, Inc.	Pasadena, California
11769	Elco Pacific	Los Angeles, California
11837	Electro Scientific Industries, Inc.	Portland, Oregon
11897	Plastiglide Mfg. Corp.	Santa Monica, California
11903	M. E. C., Inc.	Nashville, Tennessee
12060	Diodes, Inc.	Chatsworth, California
12406	Elpac, Inc.	Fullerton, California
12498	Crystalonics, Inc.	Cambridge, Massachusetts
12617	Hamlin, Inc.	Lake Mills, Wisconsin
12954	Dickson Electronics Corp.	Scottsdale, Arizona
13103	Thermolloy Co.	Dallas, Texas
13812	DialCo Electric Corp.	Brooklyn, New York
14099	Semtech Corp.	Newbury Park, California

FEDERAL SUPPLY CODE	MANUFACTURER	ADDRESS
14655	Cornell-Dubilier Electric Corp.	Newark, New Jersey
14752	Electro Cube, Inc.	South Pasadena, California
15318	Cimron Corp.	San Diego, California
15551	Kalpa Scientific Laboratories, Inc.	Flemington, New Jersey
15837	Motorola, Inc.	Arcade, New York
15849	UseCo, Inc.	Mount Vernon, New York
17109	Thermonetics, Inc.	Canoga Park, California
17227	Raytheon Co.	Mountain View, California
17452	Morgan Adhesives Co.	Stow, Ohio
17516	Moore, Maynard H. Jr., Inc.	Stoneham, Massachusetts
17826	Techno-Components Corp.	Northridge, California
17856	Siliconix, Inc.	Sunnyvale, California
18702	Ducommun Metals and Supply Co.	Los Angeles, California
18736	Voltronics Corp.	Hanover, New Jersey
21226	Executone, Inc.	New York, New York
24655	General Radio Co.	West Concord, Massachusetts
28480	Hewlett-Packard Co.	Palo Alto, California
28520	Heyman Mfg. Co.	Kenilworth, New Jersey
30874	International Business Machines Corp.	New York, New York
42190	Muter Co.	Chicago, Illinois
44655	Ohmite Mfg. Co.	Skokie, Illinois
46384	Penn Engineering and Mfg. Corp.	Doylestown, Pennsylvania
47904	Polaroid Corp.	Cambridge, Massachusetts
49671	Radio Corporation of America	New York, New York
53800	Sears Robuck and Co.	Chicago, Illinois
55026	Simpson Electric Co.	Chicago, Illinois
56289	Sprague Electric Co.	North Adams, Massachusetts
70331	Alpha Wire Corp.	New York, New York
70666	Automatic Products Co.	Detroit, Michigan
70903	Belden Mfg. Co.	Chicago, Illinois
71279	Cambridge Thermionic Corp.	Cambridge, Massachusetts
71468	I. T. T. Cannon Electric Co.	Los Angeles, California
71482	Clare, C. P. and Co.	Chicago, Illinois
71590	Centralab, Division of Globe Union, Inc.	Milwaukee, Wisconsin
71775	Cunningham, James, Son and Co.	Honeoye Falls, New York

FEDERAL SUPPLY CODE	MANUFACTURER	ADDRESS
71785	Cinch Mfg. Co.	Chicago, Illinois
72005	Driver, Wilber B., Co.	Newark, New Jersey
72314	Fairchild Camera and Instrument Corp.	Syosset, L. I., New York
72825	Eby, Hugh H., Inc.	Philadelphia, Pennsylvania
73680	Garlock, Inc.	Palmyra, New York
73899	J. F. D. Electronics Corp.	Brooklyn, New York
74970	Johnson, E. F. and Co.	Waseca, Minnesota
75237	Kayner Mfg. Co.	Pico-Riveria, California
75594	Liberty Hardware Mfg. Corp.	New York, New York
75915	Littelfuse, Inc.	Des Plaines, Iowa
76005	Lord Mfg. Co.	Erie, Pennsylvania
76530	Monadnock Mills	San Leandro, California
76545	Mueller Electric Co.	Cleveland, Ohio
78277	Sigma Instruments, Inc.	South Braintree, Massachusetts
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78929	United States Plywood Corp.	New York, New York
79094	Victory Engineering Mfg. Co.	Millvale, Pennsylvania
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pennsylvania
79963	Zierick Mfg. Corp.	New Rochelle, New York
80095	Burgess Battery Co., Battery Division	Chicago, Illinois
80112	G. C. Electronics Mfg. Co.	Los Angeles, California
80223	United Transformer Co.	New York, New York
80294	Bourns Laboratories, Inc.	Riverside, California
80368	Sylvania Electric Products, Inc.	New York, New York
80640	Stevens Arnold Co., Inc.	Boston, Massachusetts
81073	Grayhill, Inc.	La Grange, Illinois
81541	Airpax Products Co.	Cambridge, Maryland
82042	Carter Precision Electric Co.	Skokie, Illinois
83330	Smith, Herman H., Inc.	Brooklyn, New York
84171	Arco Electronics, Inc.	Great Neck, New York
86270	Bendix Corp.	Baltimore, Maryland
90002	Hubbel, Harvey, Inc.	New York, New York
90201	Mallory, P. R. and Co., Inc.	Detroit, Michigan
91833	Keystone Electronics Corp.	New York, New York
92379	Burroughs Corp.	Chicago, Illinois

FEDERAL SUPPLY CODE	MANUFACTURER	ADDRESS
92607	Tensolite Insulated Wire Co., Inc.	Tarrytown, New York
94222	South Chester Corp.	Chester, Pennsylvania
95264	Lynn Electronics Research Co.	Burbank, California
95348	Gordos Corp.	Bloomfield, New Jersey
95354	Methode Mfg. Co.	Chicago, Illinois
95566	Arnold Engineering Co.	Marengo, Illinois
97564	Pendar, Inc.	Coeur D Alene, Idaho
98291	Sealectro Corp.	Mamaroneck, New York
98978	International Electronics Research Corp.	Burbank, California

CIMRON
CORPORATION

ELECTRONICS FOR MEASUREMENT – CONTROL – AUTOMATIO